Installation Restoration Program
Final Phase II Remedial Investigation Report

143rd Combat Communications Squadron
Seattle Air National Guard Station
Washington Air National Guard
Seattle, Washington

August 1999

Air National Guard
Andrews AFB, Maryland

KCSlip4 41241

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Prepared For:

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Definition
AGE	Aerospace Ground Equipment
amsl	Above mean sea level
ANG	Air National Guard
ANG/CEVR	Air National Guard/Installation Restoration Program Branch
ANGS	Air National Guard Station
AOC	Area of concern
ARAR	Applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
bgs	Below ground surface
Boeing	The Boeing Company
°C	Degrees Celsius
CCSQ	Combat Communications Squadron
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COPC	Contaminants of potential concern
CPF	Carcinogenic Potency Factor
DCE	Dichloroethene
DD	Decision Document
DERP	Defense Environmental Restoration Program
EDR	Environmental Data Resources, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
ERM	Environmental Resources Management
°F	Degrees Fahrenheit
FS	Feasibility Study
GPR	Ground penetrating radar
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
kg	Kilogram
Koc	Organic carbon/water partition coefficient
LTM	Long-term monitoring
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/kg/day	Milligrams per kilogram per day
mg/kg	Milligrams per kilogram

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Definition
mg/l	Milligrams per liter
µg/l	Micrograms per liter
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
OpTech	Operational Technologies Corporation
OSHA	Occupational Safety and Health Act
PA	Preliminary Assessment
PA/SI	Preliminary Assessment/Site Inspection
PCE	Tetrachloroethylene
pCi/g	PicoCuries per gram
PID	Photoionization detector
PM_{10}	Particulate matter less than 10 microns
PP	Priority pollutant
PREE/CA	Presumptive Remedy Engineering Evaluation/Cost Analysis
PSG	Project screening goal
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality assurance/quality control
QC	Quality control
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Inspection
SMCL	Secondary Maximum Contaminant Level
SVOC	Semivolatile organic compound
TCE	Trichloroethene
TPH	Total petroleum hydrocarbons
TSD	Treatment, storage, or disposal
TVH	Total volatile hydrocarbons
UCL	Upper confidence limit
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Definition
VOC	Volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology

EXECUTIVE SUMMARY

As part of the Department of Defense Installation Restoration Program (IRP) used to investigate potentially contaminated sites on Air National Guard property, Environmental Resources Management (ERM) conducted a Remedial Investigation (RI) at the Washington Air National Guard's Seattle Air National Guard Station (Seattle ANGS). The Seattle ANGS occupies approximately 7.5 acres near the north end of the King County International Airport (Boeing Field) in Seattle, Washington. A Preliminary Assessment/Site Inspection conducted at the Seattle ANGS in 1994 recommended further investigation of the site's area of concern, hereafter referred to as IRP Site 1 - Burial Site.

The RI was conducted in two phases. Phase I was conducted in 1996 and 1997, and included the collection of storm sewer catch basin samples, surface and subsurface soil samples, screening-level groundwater samples (using direct-push technology), and the installation and quarterly sampling of groundwater monitoring wells. Aquifer tests also were conducted to estimate the hydraulic conductivity of the shallow groundwater-bearing unit at the site. Phase II was conducted in 1998 and 1999, and included the collection of soil vapor samples, additional subsurface soil samples and screening-level groundwater samples, and the installation and quarterly sampling of additional groundwater monitoring wells.

Soil samples collected at the Seattle ANGS indicate that the near-surface geology consists of approximately 8 feet of silty sand fill material underlain by a fine-grained sand that is uniform to at least the maximum depth explored during the RI (approximately 21 feet below ground surface). Unconfined groundwater occurs at approximately 6 to 10 feet below ground surface. The inferred groundwater flow direction is toward the south-southeast. Hydraulic conductivity estimates derived from aquifer slug tests range from 1.25×10^{-4} to 6.09×10^{-4} feet per second (3.29 to 16.04 meters per day).

Project screening goals (PSGs) were developed for constituents detected in soil and groundwater samples collected during the RI. The PSGs were derived from chemical-specific applicable or relevant and appropriate requirements and site-specific background concentration data. No contaminants of potential concern (COPCs) were detected in soil at concentrations above PSGs. COPCs detected in groundwater at concentrations above PSGs include the volatile organic compounds (VOCs) benzene, tetrachloroethene, and trichloroethene.

Benzene was detected at a concentration of 7.6 micrograms per liter (μg/l) in one screening-level groundwater sample collected in the southern portion of the Station. The Washington State Model Toxics Control Act (MTCA) Method A Cleanup Level for benzene is 5 μg/l. Benzene has not been detected in groundwater samples collected from monitoring wells.

Tetrachloroethene was detected above the MTCA Method A Cleanup Level of 5 μg/l in four groundwater samples collected from two background monitoring wells along the northern Station boundary. The maximum concentration detected was 17 μg/l.

Trichloroethene (TCE) was detected above the MTCA Method A Cleanup Level of 5 μg/l in six groundwater samples collected in the southern portion of the Station (three screening-level samples and three collected from monitoring wells). The maximum concentration detected was 83 μg/l.

The source of the VOCs detected in groundwater has not been identified. The RI findings suggest that the VOCs are unrelated to past or present activities at the Seattle ANGS. The TCE detected in the southern portion of the Station may be related to a dissolved TCE plume that exists beneath the Boeing site immediately south of the Seattle ANGS; TCE concentrations up to 1,000 μg/l have been reported in shallow groundwater at this site.

Based on the results of the RI, continued quarterly groundwater monitoring for 1 year is recommended to assess trends in VOC concentrations and to evaluate compliance with MTCA.

SECTION 1.0

INTRODUCTION

This report describes the Remedial Investigation (RI) conducted at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. The RI was conducted as part of the Air National Guard (ANG) Installation Restoration Program (IRP) under Contract DAHA90-94-0014, Delivery Orders 0032 and 0051. The Air National Guard/Installation Restoration Program Branch (ANG/CEVR) provided technical and project management oversight for this investigation on behalf of the ANG. The RI Report follows the general format recommended by ANG/CEVR and contains the basic contents suggested in the United States Environmental Protection Agency (USEPA) document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988).

The RI was conducted in two phases: Phase I, conducted in 1996 and 1997, and Phase II, conducted in 1998 and 1999. The objectives of the RI were to: 1) evaluate the nature and extent of potential contamination related to IRP Site 1 - Burial Site; 2) assess site-specific background concentrations of contaminants of potential concern (COPCs) in soil and groundwater; and 3) provide recommendations for additional remedial actions as appropriate.

1.1 Report Organization

This Phase II RI Report provides a summary of the activities for the RI and is organized into 11 sections and 7 appendices. The contents of the sections are as follows:

- Section 1.0 provides general introductory information for this report;
- Section 2.0 provides background information for the Seattle ANGS, including a summary of the Phase I RI and other previous investigations;
- Section 3.0 summarizes the environmental setting in the vicinity of the Seattle ANGS;

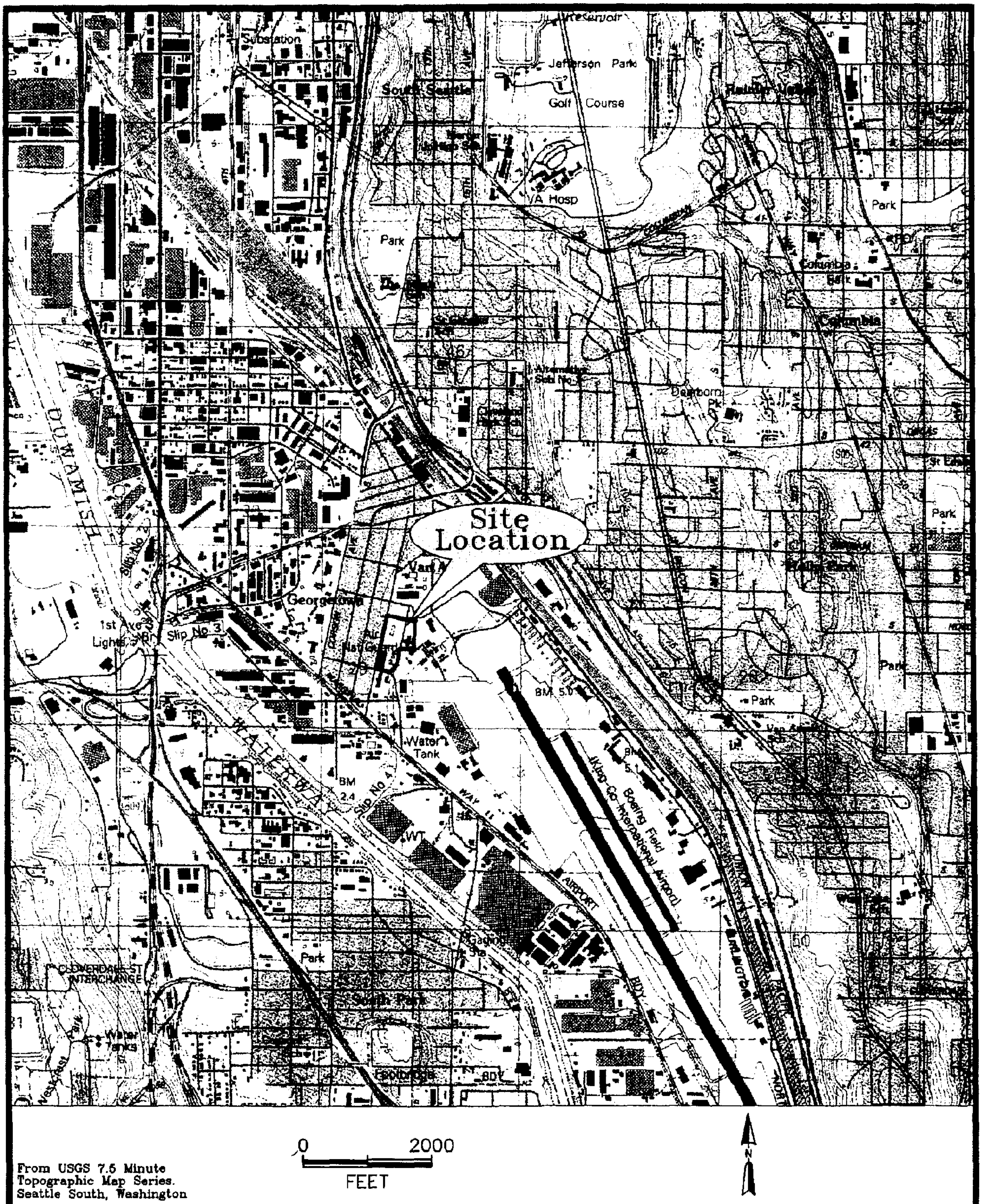
- Section 4.0 describes the Phase II field investigation program;
- Section 5.0 describes the Phase II investigation findings;
- Section 6.0 discusses Federal and State applicable or relevant and appropriate requirements (ARARs);
- Section 7.0 discusses contaminant fate and transport;
- Section 8.0 discusses risk assessment;
- Section 9.0 presents conclusions;
- Section 10.0 presents recommendations; and
- Section 11.0 lists references.

The following appendices are included with this report:

- Appendix A contains technical memoranda for Phase II field activities;
- Appendix B contains Phase II borehole logs and well construction diagrams, including field-screening data;
- Appendix C contains land survey data for the RI sampling locations;
- Appendix D contains information regarding investigation-derived waste management;
- Appendix E lists the repositories of laboratory analytical data packages;
- Appendix F contains quality control (QC) data review/validation reports for the Phase II analytical data; and
- Appendix G contains Phase II Chain-of-Custody records.

1.2 Site Information

The Seattle ANGS is at 6736 Ellis Avenue South in Seattle, Washington (Figure 1-1). The Station occupies approximately 7.5 acres near the north end of the King County International Airport (Boeing Field).



From USGS 7.5 Minute Topographic Map Series. Seattle South, Washington

FIGURE 1-1	LOCATION MAP OF SEATTLE AIR NATIONAL GUARD STATION SEATTLE, WASHINGTON 143rd CCSQ, Seattle ANGS Seattle, Washington	ERM

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Previous IRP investigations completed at the Seattle ANGS include the following:

- A Preliminary Assessment (PA) completed in 1993 by the ANG;
- A Preliminary Assessment/Site Inspection (PA/SI) conducted in 1994 by Operational Technologies Corporation (OpTech); and
- A Phase I RI conducted in 1996 and 1997 by Environmental Resources Management (ERM).

Background information regarding previous investigations is provided in Section 2.0 of this report.

1.3 Installation Restoration Program Information

The Defense Environmental Restoration Program (DERP) was established in 1984 to promote and coordinate efforts for the evaluation and cleanup of contamination at Department of Defense (DOD) installations. On 23 January 1987, Presidential Executive Order 12580 was issued which assigned the responsibility for carrying out DERP within the overall framework of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) to the Secretary of Defense. The IRP was established under DERP to identify, investigate, and remediate contamination at DOD installations. The IRP focuses on cleanup of contamination associated with past DOD activities to ensure that threats to public health are eliminated and to restore natural resources for future use.

The IRP is divided into several phases as illustrated on Figure 1-2. These phases are defined and described in the following subsections.

1.3.1 Preliminary Assessment

The PA consists of personnel interviews and a record search designed to identify and evaluate past disposal and/or spill sites that might pose a potential or actual hazard to public health, public welfare, or the environment. Previously undocumented information is obtained through the interviews. The record search focuses on obtaining useful information

FIGURE 1-2

INSTALLATION RESTORATION PROGRAM DECISION FLOW DIAGRAM

143rd CCSQ, Seattle ANGS
Seattle, Washington

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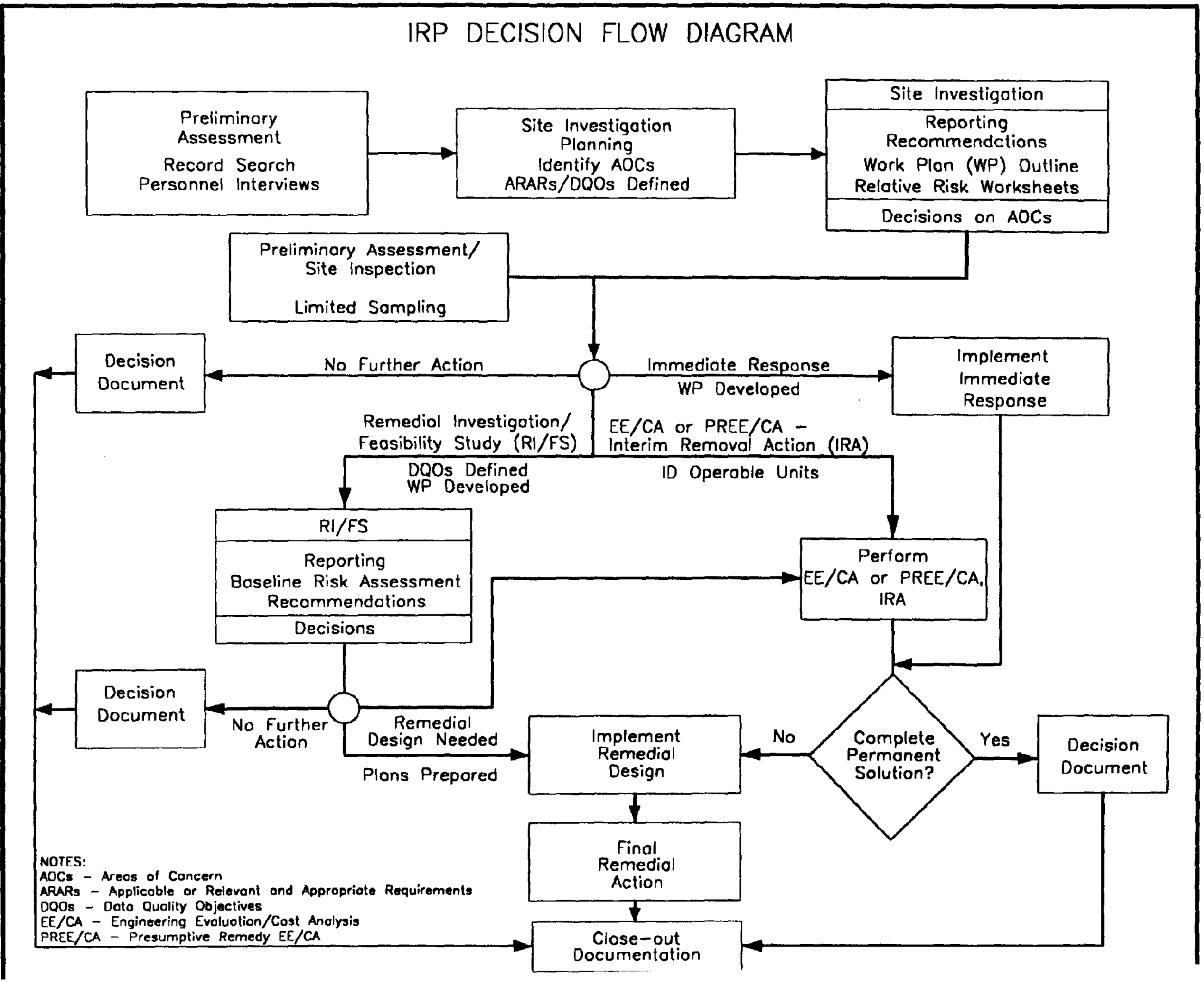

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from aerial photographs, installation plans, facility inventory documents, lists of hazardous materials used, subcontractor reports, correspondence, Material Safety Data Sheets, Federal and state agency reports, documents from local government offices, and various standard reference sources.

1.3.2 Site Inspection

The purpose of the Site Inspection (SI) is to perform limited sampling and other field activities to confirm the presence or absence of contamination at potential areas of concern (AOCs) identified during the PA. This may include, for example, geophysical surveys, field-screening, soil sampling, and limited groundwater sampling for suspected contaminants. The SI may be conducted in conjunction with the PA. Data collected during the PA and SI may be sufficient to reach a decision point for a site, such as no further IRP action is warranted, prompt removal of contaminants is necessary, or further IRP work is required.

1.3.3 Site Investigation

Like the SI, the Site Investigation consists of field activities designed to confirm the presence or absence of contamination at potential AOCs identified during the PA. However, the Site Investigation typically includes more extensive sampling and evaluation of groundwater than the SI. An additional objective of the Site Investigation is to determine potential risks to human health and the environment.

The activities undertaken during the Site Investigation generally fall into three categories: screening, confirmation, and optional activities. Screening activities are conducted to gather additional preliminary data not obtained during the PA. Confirmation activities include specific media sampling and laboratory analysis to confirm either the presence or the absence of contamination, chemical concentrations, and the potential for migration of contaminants. Information obtained during the subsurface investigation is utilized to define AOCs from among the potential AOCs identified during the PA. Site hydrology, geology, and soil properties are also characterized during the Site Investigation. Additional data may be needed to reach a decision point for a site. Optional activities may be conducted to obtain the additional data needed.

The general approach of the Site Investigation is to sequence the field activities so that data are acquired and used as the field investigation progresses. This is done to determine the presence or absence of contamination in a relatively short time period, optimize data collection and data quality, and minimize costs.

1.3.4 Remedial Investigation

The objectives of the RI are to determine the nature and extent of contamination at a site, determine the nature and extent of potential threats to human health and the environment, and provide a basis for determining the types of response actions to be considered (Decision Document, Feasibility Study [FS], Remedial Design [RD], or Remedial Action [RA]).

The RI consists of field activities designed to quantify contaminant concentrations, the spatial extent of the contamination, and the potential pathways of contaminant migration. Field activities may include the installation of soil borings and/or monitoring wells and the collection and analysis of water, soil, and/or sediment samples. Careful documentation and quality control procedures are implemented during RI field activities in accordance with CERCLA and SARA guidelines to ensure the validity of the collected data.

Hydrogeologic studies are conducted to determine the underlying strata, groundwater flow rates, and direction of potential contaminant migration.

A baseline risk assessment, which provides an evaluation of the potential threat to human health, is conducted prior to implementing any RA. The baseline risk assessment provides the basis for determining whether RA may be necessary to mitigate endangerment to public health.

The findings from the RI will result in the selection of one of the following options:

- No Further Action: The results of investigations do not indicate harmful concentrations of chemicals that pose a significant threat to human health or the environment. Therefore, no further IRP action is warranted and a decision document will be prepared to close the site.

- Long-Term Monitoring (LTM): The results of investigations do not indicate the presence of sufficient contamination to justify costly RA. LTM may be recommended to detect the possibility of future problems.

- FS: The results of investigations confirm the presence of contamination that may pose a current or future threat to human health and/or the environment, and RA may be necessary.

1.3.5 Feasibility Study

Based on the results of the RI, the baseline risk assessment, and a review of state and Federal regulatory requirements, an FS may be conducted to develop, screen, and evaluate alternatives for remediation of groundwater and/or soil contamination at the site. The overall objectives of the FS include providing information necessary for remedial alternative development and evaluating information to support selection of a remedy that is protective of human health and the environment; considers ARARs; satisfies the preference for treatment that significantly and permanently reduces toxicity, mobility, or volume of hazardous constituents as a principal element; and is cost-effective.

Activities associated with the FS include the following:

- Identification of applicable remediation technologies/RAs;
- Preliminary screening of technologies;
- Development and screening of remedial alternatives;
- Detailed analysis of alternatives;
- Comparative analysis of alternatives; and
- Completion of an FS report.

The end result of the FS is the selection of the most appropriate remedial alternative with concurrence by state and/or Federal regulatory agencies.

1.3.6 Engineering Evaluation/Cost Analysis

At any time during the course of an IRP project, an Engineering Evaluation/Cost Analysis (EE/CA) can be implemented to evaluate remedial solutions for contamination. An EE/CA can be completed for all non-time-critical removal actions that are not addressed by an FS. In general, an EE/CA is similar to a Remedial Investigation/Feasibility Study (RI/FS) but is less comprehensive because of the presumption of a specific RA. An EE/CA is usually completed as a parallel effort to an RI/FS. The overall objectives of the EE/CA include satisfying environmental review and administrative requirements for removal actions; providing a framework for evaluating and selecting alternative technologies; satisfying the preference for treatment that significantly and permanently reduces toxicity, mobility, or volume of hazardous constituents as a principal element; and maximizing cost-effectiveness.

The goals of the EE/CA are to:

- Develop an Approval Memorandum;
- Identify removal action objectives;
- Identify and analyze removal action alternatives;
- Compare removal action alternatives; and
- Recommend removal action alternatives in an Action Memorandum.

The end result of the EE/CA is the selection of the most appropriate removal action with concurrence by state or Federal regulatory agencies.

1.3.7 Presumptive Remedy Engineering Evaluation/Cost Analysis

A Presumptive Remedy Engineering Evaluation/Cost Analysis (PREE/CA) may be performed if the results of investigations indicate the presence of sufficient contamination to justify RA prior to completion of an FS, and the technology required for the RA is evident. A PREE/CA may be recommended to evaluate the effectiveness and costs associated with the presumptive RAs.

1.3.8 Remedial Design

The RD involves development and approval of the engineering designs required to implement the selected remedial alternative identified in the FS.

1.3.9 Remedial Action

The RA is the actual implementation of the remedial alternative. It refers to the accomplishment of measures to eliminate the hazard or reduce it to an acceptable level. Examples of remedial measures that might be selected include covering a landfill with an impermeable cap, pumping and treating contaminated groundwater, installing a new water distribution system, and in-situ bioremediation of contaminated soils. In some cases, after the RAs have been completed, an LTM program may be implemented as a precautionary measure to detect contaminant migration or to document the effectiveness of remediation.

1.3.10 Immediate Action Alternatives

At any point, it may be determined that contamination at a site poses an immediate threat to public health or the environment, thus necessitating prompt removal of the threat. Immediate action, such as limiting access to the site, capping or removing contaminated soils, and/or providing an alternative water supply may suffice as effective control measures. Sites where immediate actions are implemented maintain their IRP status in order to determine the need for additional RA or LTM. Removal actions or other appropriate RAs may be implemented during any phase of an IRP project.

SECTION 2.0

INSTALLATION BACKGROUND

This section describes the Seattle ANGS and the associated IRP site, and summarizes the waste disposal history of the facility, the results of regulatory records reviews, and previous IRP investigations at the Station. Information presented in this section was derived from the PA/SI Report (OpTech 1995) and the Phase I RI Report (ERM 1998a).

2.1 Installation Description

The Seattle ANGS is the home of the 143rd Combat Communications Squadron (CCSQ). The Station is at 6736 Ellis Avenue South in Seattle, Washington, and occupies approximately 7.5 acres near the north end of the King County International Airport (Boeing Field). The facility employs 129 personnel, of which 25 are full-time employees. A map of the site is shown on Figure 2-1.

2.1.1 Installation History

The Seattle ANGS was built during World War II by the War Department and was used by the United States Army Air Corps as the "Aircraft Factory School" during the war. In 1948 the property was given to King County as surplus property and was subsequently leased to the Washington ANG.

On 21 April 1948, the 143rd Aircraft Control and Warning Squadron was established. From May 1951 to February 1953, the 143rd was activated for recruitment purposes. During this period the unit had two C-47 aircraft. In 1960 the name of the unit was formally changed to the 143rd Communications Squadron Tributary Teams. In 1969 and 1988 the name of the unit was again changed, becoming the 143rd Mobile Communications Squadron and the 143rd CCSQ, respectively. The current mission of the 143rd CCSQ is to provide mobile communication equipment and support for airports and airfields.

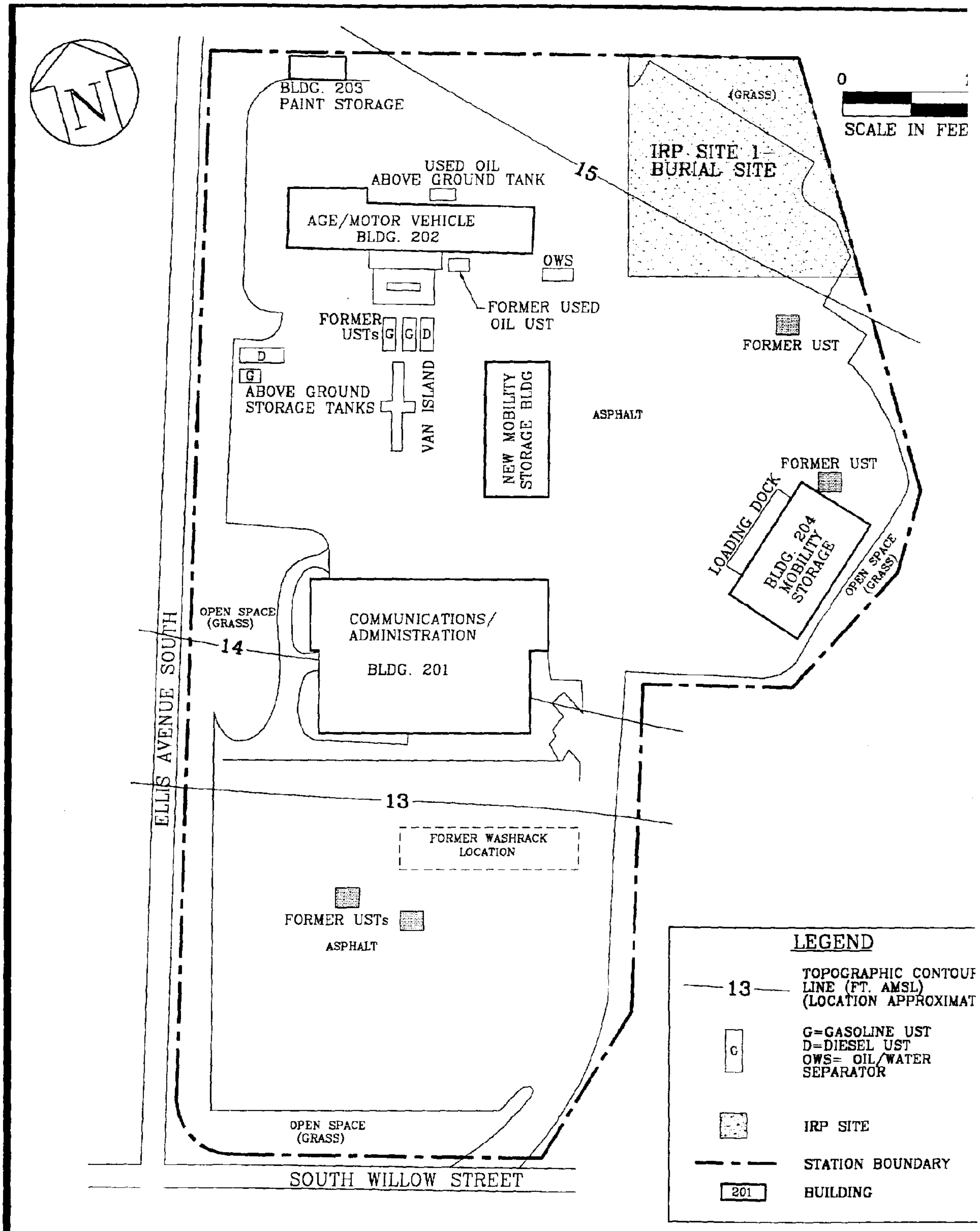

FIGURE 2-1

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SITE MAP

143rd CCSQ, Seattle ANGS
Seattle, Washington

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In 1948 the Station consisted of 17 acres of land, including an aircraft parking ramp, leased from King County. At that time the property contained 15 buildings, all of which were subsequently demolished. In 1951 a new property lease decreased the size of the Station from 17 acres to 7.5 acres. Buildings were constructed for headquarters, a mess hall, warehouses, and vehicle service requirements. In 1980 the National Guard Bureau approved and Congress funded the replacement of all buildings. The buildings were completed in 1984 with the exception of Building 204 (Mobility Storage), which was completed in 1988, and the new Mobility Storage Building, which was completed in 1998. The Seattle ANGS currently consists of 7.5 acres and five buildings (Figure 2-1). The Seattle ANGS property is leased from King County by the United States Air Force, which in turn licenses the property to the Washington State Military Department for ANG use.

2.1.2 Adjacent Land Use

Land use adjacent to the Seattle ANGS is shown on Figure 2-2. Adjacent properties to the north, south, and east of the Station are zoned for general industrial use, are currently used for industrial purposes, and have a history of industrial use. The properties directly south and east of the Station are owned by The Boeing Company (Boeing) or leased by Boeing from King County. Immediately north of the Station are several trucking companies and a Washington State Motor Pool auto maintenance facility. The area west of the Station, across Ellis Avenue South, consists of residential properties.

2.1.3 IRP Site 1 - Burial Site Description

As shown on Figure 2-1, IRP Site 1 (the IRP site) is located in the northeast corner of the Seattle ANGS. The IRP site is approximately 175 feet long and 175 feet wide. The north and east sides of the IRP site are bounded by a 6-foot-high fence. With the exception of the grass-covered northeast corner, the site is covered with asphalt and is used as a vehicle parking area.

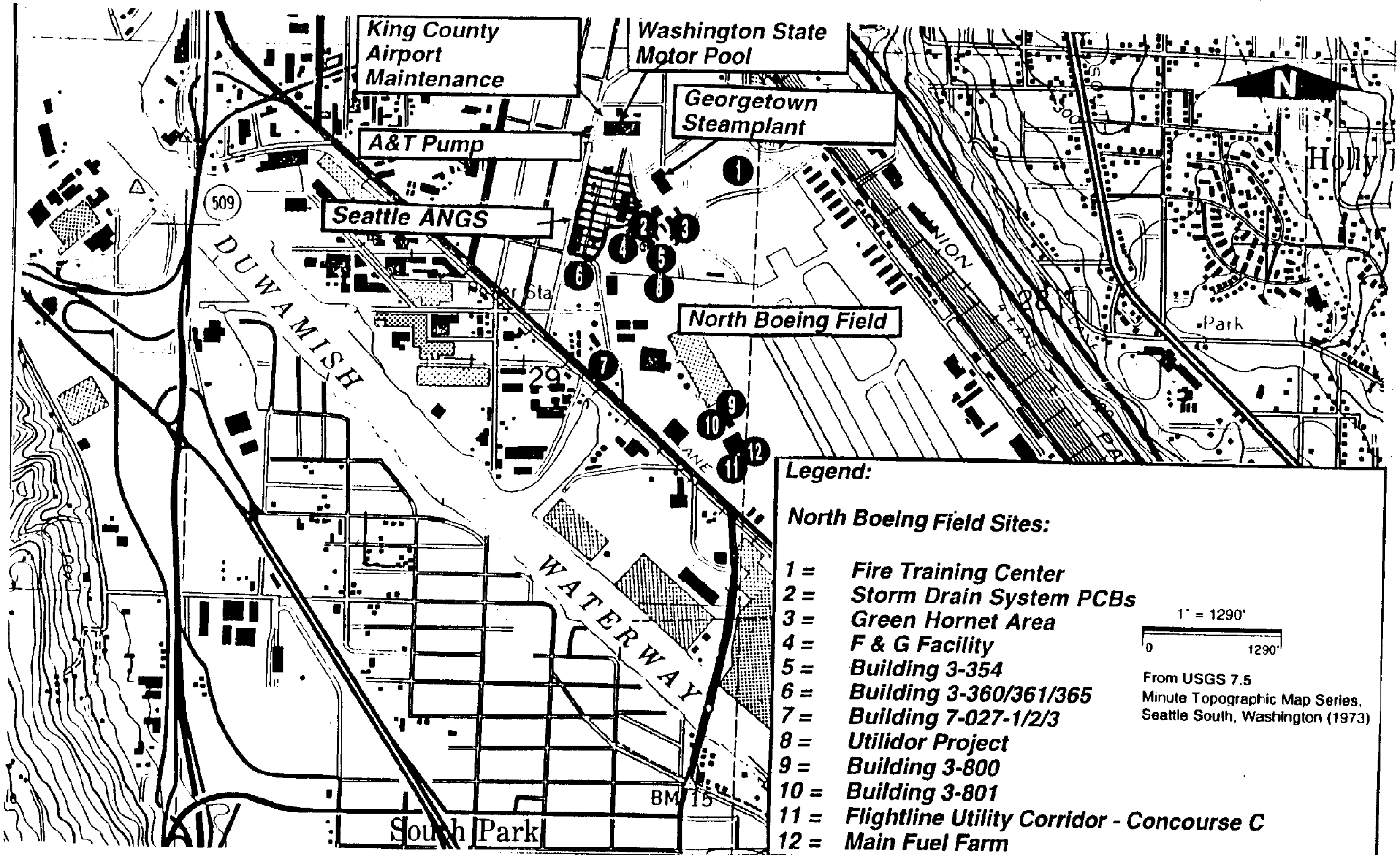

FIGURE 2-2

ADJACENT LAND USE AND
SITES OF ENVIRONMENTAL CONCERN

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

2.2 Waste Disposal History

This section summarizes the results of the PA/SI regarding hazardous materials and wastes generated, historical and current disposal practices, and past environmental incidents and problems at the Seattle ANGS.

The information presented in the PA/SI Report is based on interviews with past and present Station employees, a review of Station records and other pertinent information, and a field survey.

2.2.1 Wastes Generated by Installation Operations

A variety of wastes were burned and/or buried at the IRP site from the early 1950s through 1968. The wastes most likely disposed of at the IRP site include radio tubes, solvents, waste motor oils, kerosene, batteries, brake fluid, spray paints, paint thinners or removers, methyl ethyl ketone, xylene, and naptha (OpTech 1995). These wastes were generated by the Aerospace Ground Equipment (AGE)/Motor Vehicle Maintenance Building, the former Power Production Building, and the Communications/Administration Building.

2.2.2 Disposal Practices at the Station

Historical disposal practices at the Seattle ANGS included land disposal within the IRP site and off-site disposal. Currently, discarded hazardous materials and hazardous wastes are collected and disposed of either by an appropriately licensed contractor or through the Defense Reutilization and Marketing Office at Fort Lewis, Washington.

2.2.3 Past Environmental Incidents and Problems

Small amounts of hazardous materials are reported to have been released to the environment at the Station in the past (OpTech 1995). The PA/SI Report identified the IRP site as the only potentially contaminated disposal site at the Station.

2.3 Regulatory Records Review

The PA/SI Report identified several sites in the vicinity of the Seattle ANGS with potential or documented environmental contamination. Environmental conditions at nearby properties were further evaluated during preparation of the Phase I RI/FS Work Plan (ERM 1996) and during review of the Phase II RI data. The results are summarized below.

An Environmental Data Resources, Inc., (EDR) summary report was prepared on the location and status of sites of potential environmental concern within a 1-mile radius of the Seattle ANGS. The EDR database search identified 19 sites within a 1-mile radius of the Station that appear on the Washington Department of Ecology's (WDOE's) Confirmed and Suspected Contaminated Sites (CSCS) Report. The EDR database search also identified 14 leaking underground storage tank sites within 1/2 mile of the Station. In addition, one sensitive receptor category, a daycare center, was identified within 1/4 mile of the Station.

The second phase of the regulatory records review included a review of WDOE's files for additional information regarding selected sites on the CSCS Report. These sites include:

- North Boeing Field (12 sites), Ellis Avenue South & Marginal Way;
- King County Airport Maintenance, 6518 Ellis Avenue South;
- Washington State Motor Pool, 6650 Ellis Avenue South;
- Seattle City Light - Georgetown Steamplant, 1131 South Elizabeth Street; and
- A & T Pump, 6525 Ellis Avenue South.

The locations of these sites relative to the Seattle ANGS are shown on Figure 2-2. Details regarding previous investigations and documented contamination at these sites are presented in the Phase I RI/FS Work Plan (ERM 1996).

Since 1991, trichloroethene (TCE) has been consistently detected at concentrations up to 1,000 micrograms per liter (μg/l) in shallow groundwater beneath the Boeing site immediately south of the Seattle ANGS (Boeing 1998). The groundwater data for this site (identified as North Boeing Field Site 6 on Figure 2-2) define a dissolved TCE plume extending from near the north end of the site to properties off-site to the south; the highest concentrations were detected near the middle of the site. Groundwater elevation data indicate that the Boeing site is hydraulically downgradient of the Seattle ANGS (ERM 1996; Section 5.1 of this report). Nevertheless, given the relatively high concentrations and the proximity of the Boeing TCE plume to the Seattle ANGS, potential transport of TCE from the Boeing site onto the ANGS site (via diffusional spreading at the plume's upgradient edge, for example) cannot be discounted.

2.4 Previous Investigations

This section summarizes previous investigations conducted as part of the IRP at the Seattle ANGS.

2.4.1 Preliminary Assessment

The ANG completed a PA for the Seattle ANGS in 1993. The PA focused on historical and current hazardous materials and hazardous waste generation, use, handling, and disposal practices at the Station. Based on the results of the PA, the IRP site was identified as potentially contaminated with hazardous materials/hazardous waste and was recommended for further IRP investigation.

2.4.2 Preliminary Assessment/Site Inspection

A PA/SI was conducted at the Station in 1994 by OpTech. This section summarizes the scope of work and results of the PA/SI field activities. The PA/SI scope of work is described in further detail in the Phase I RI Report (ERM 1998a).

2.4.2.1 Scope of Work

The purpose of the PA/SI was to identify AOCs and to confirm the presence or absence of soil and groundwater contamination associated with past hazardous material and hazardous waste handling and disposal practices at the Station. In addition to the identification of AOCs, the scope of the PA/SI included defining the nature of known or suspected releases at the AOCs; identifying potential receptors; confirming the presence or absence of soil and groundwater contamination; describing the geologic conditions of the study area; and defining hydrogeologic conditions such as groundwater flow direction. The PA/SI scope of work did not include determination of the source or extent of contamination at the IRP site or assessment of possible threats to human health and the environment.

Field work for the PA/SI was performed in June and July 1994. Screening activities at the IRP site included a ground penetrating radar (GPR) survey, a magnetometer survey, and a shallow soil vapor survey. Confirmation activities at the IRP site included collection of subsurface soil samples from soil borings and monitoring well borings, and installation and sampling of groundwater monitoring wells.

2.4.2.2 Geophysical Investigation Results

The GPR survey revealed an anomalous soil horizon or disturbed soil area in the southwest portion of the IRP site, with an upper interface approximately 4.5 to 6.0 feet below ground surface (bgs). The origin of this anomalous soil material was interpreted as being associated either with the filling-in of a former Duwamish River meander or with the historical waste burial or burning activities at the IRP site. Magnetometer data collected at the IRP site did not reveal any significant metal masses buried within the area of disturbed soil (OpTech 1995).

2.4.2.3 Soil Vapor Survey Results

Soil vapor samples were collected within 5 feet of the ground surface from 21 locations at the IRP site. The samples were analyzed for total volatile hydrocarbons (TVH). Local areas of slightly elevated TVH concentrations were identified at the IRP site (Figure 2-3). The results of the soil vapor survey were used to determine the final placement of soil borings.

2.4.2.4 Results of Soil and Groundwater Analyses

The PA/SI soil and groundwater sampling locations are shown on Figure 2-4. The analytical results for the soil and groundwater samples collected during the PA/SI are summarized on Tables 2-1 and 2-2, respectively. For comparison, project screening goals (PSGs) developed during the Phase I RI are also shown on Tables 2-1 and 2-2. The PSGs were developed from Washington State Model Toxics Control Act (MTCA) Method A Cleanup Levels, MTCA Method B Formula Values, regional and site-specific background concentrations, and/or Federal Maximum Contaminant Levels (MCLs) for drinking water. PSGs are discussed further in Section 5.2.

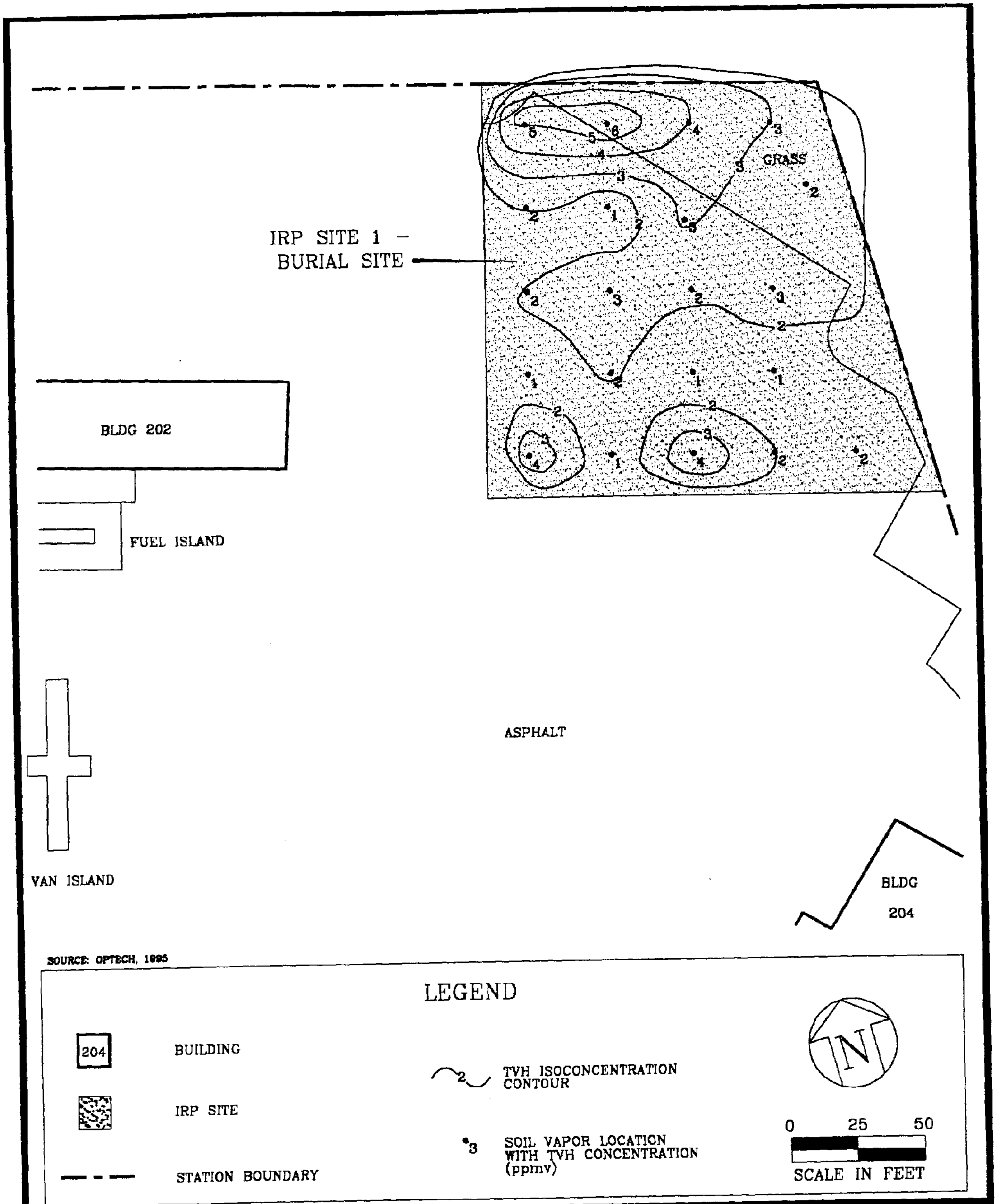

FIGURE 2–3

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PA/SI SOIL VAPOR SURVEY RESULTS
TOTAL VOLATILE HYDROCARBONS
IRP SITE 1 – BURIAL SITE
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

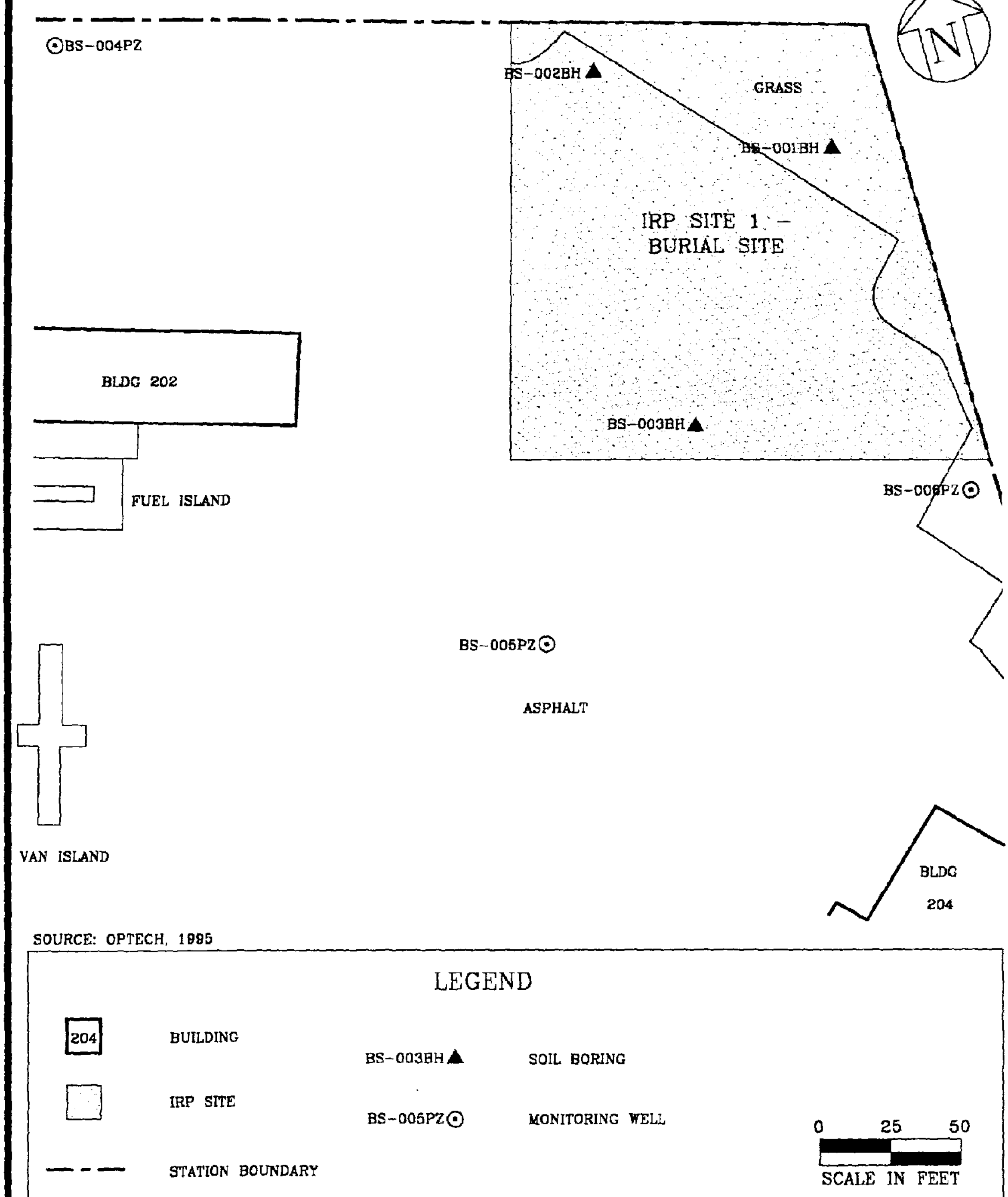

FIGURE 2-4

LOCATION OF PA/SI SOIL BORINGS AND MONITORING WELLS
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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TABLE 2-1

Summary of PA/SI Soil Chemical Quality Data
143rd CCSQ, Seattle ANGS, Seattle, Washington
Source: OpTech 1995

Location	Sample Depth (ft-bgs)	Volatile Organic Compounds (USEPA Method 8240) (µg/kg)	Semivolatile Organic Compounds (USEPA Method 8270) (µg/kg)	Total Petroleum Hydrocarbons (WTPH-D, G) (mg/kg)	Polychlorinated Biphenyls (USEPA Method 8080) (µg/kg)	Radionuclides (USEPA Method 9310) (pCi/g)		Trace Metals (mg/kg)												
			Di-n-butylphthalate			Gross Alpha	Gross Beta	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
Background (BS-004PZ)	8.5 - 10.0	ND	2,240	ND	ND	0 ± 17	0 ± 32	ND	2	1.2	1.6	10	40	34	ND	13	ND	ND	0.056	25
BS-001BH	1.0 - 2.5	ND	1,750	ND	ND	4 ± 27	2 ± 35	ND	0.33	1	1.6	11	130	28	ND	14	0.053	0.18	0.038	19
	5.5 - 7.0	ND	1,680	ND	ND	0 ± 18	4 ± 36	ND	1.6	0.82	1.1	11	16	16	ND	5.8	ND	ND	0.03	8.6
	8.5 - 10.0	ND	1,590	ND	ND	0 ± 20	0 ± 24	ND	0.033	0.29	0.66	7.9	9.3	9.7	ND	5.6	ND	ND	ND	14
BS-002BH	1.0 - 2.5	ND	1,640	ND	ND	2 ± 25	3 ± 37	ND	2.7	0.87	1.3	10	23	28	ND	9.3	ND	ND	0.024	31
	5.5 - 7.0	ND	900	ND	ND	2 ± 25	0 ± 36	ND	1.1	0.49	0.92	14	23	15	ND	6.2	ND	ND	0.054	16
	8.5 - 10.0	ND	1,960	ND	ND	2 ± 25	0 ± 34	ND	0.63	0.34	0.75	9.3	7.5	10	ND	7.2	ND	ND	ND	20
BS-003BH	2.0 - 3.5	ND	ND	780*	ND	2 ± 20	2 ± 30	ND	4.1	1	1.3	11	20	27	ND	8.6	ND	ND	0.053	19
	5.5 - 7.0	ND	744	160*	ND	0 ± 21	0 ± 34	ND	20	1.1	1.5	15	33	62	ND	14	ND	0.042	0.093	40
	8.5 - 10.0	ND	1,750	ND	ND	0 ± 21	0 ± 34	ND	3.7	0.58	1	12	14	29	ND	8.3	0.11	ND	ND	20
RI Project Screening Goal				100/200 (1)		9.96	16.1		20		2	100	2,960	250		1,600	400			24,000
	ARAR		8,000,000 (a)							0.233 (b)								400 (a)	5.6 (a)	
Natural Background (c)									7.3	0.61	0.77	48.15	36.36	16.83		38.19	0.78	0.61	NA	85.06

PA/SI = Preliminary Assessment/Site Inspection
RI = Remedial Investigation
USEPA = United States Environmental Protection Agency
ft-bgs = Feet below ground surface
µg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
pCi/g = PicoCuries per gram
WTPH-D,G = Washington Total Petroleum Hydrocarbons - diesel, gasoline
ND = Not detected above laboratory method reporting limit
NA = Not available
ARAR = Applicable or relevant and appropriate requirement for constituents detected during the PA/SI that were not detected during the RI.
(1) Project screening goal (PSG) for TPH-G = 100 mg/kg; PSG for TPH-D = 200 mg/kg.
(a) = Model Toxics Control Act Method B Non-Cancer Formula Value.
(b) = Model Toxics Control Act Method B Cancer Formula Value.
(c) = 90th percentile value for the Puget Sound Region (As, Be, Cd, Cr, Cu, Pb, Ni, and Zn) or Washington State (Se and Ag) (Washington State Department of Ecology, 1994b).
* = These values were based on analysis for total petroleum hydrocarbons by USEPA Method 418.1. The WTPH-D,G analyses yielded ND results.
Shaded cells indicate a detection above the associated RI project screening goal or ARAR.

<u>Constituent Abbreviations</u>

Sb = Antimony	Cu = Copper	Tl = Thallium
As = Arsenic	Hg = Mercury	Pb = Lead
Be = Beryllium	Ni = Nickel	Zn = Zinc
Cd = Cadmium	Se = Selenium	
Cr = Chromium	Ag = Silver	

TABLE 2-2

Summary of PA/SI Groundwater Chemical Quality Data
143rd CCSQ, Seattle ANGS, Seattle, Washington
Source: OpTech 1995

Location	Volatile Organic Compounds (USEPA Method 8240) (µg/l)	Semivolatile Organic Compounds (USEPA Method 8270) (µg/l)	Total Petroleum Hydrocarbons (WTPH-D) (µg/l)	Polychlorinated Biphenyls (USEPA Method 8080) (µg/l)	Radionuclides (USEPA Method 9310) (pCi/l)		Trace Metals* (µg/l)												
					Gross Alpha	Gross Beta	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Se	Tl	Zn
Background (BS-004PZ)	ND	ND	ND	ND	**36 ± 42**	**78 ± 25**	ND	**38**	**13**	0.6	**120**	290	**33**	ND	**160**	ND	ND	**5.7**	450
BS-005PZ	ND	ND	ND	ND	15 ± 39	**77 ± 24**	ND	**28**	**540**	ND	5.2	54	**22**	ND	31	ND	2	ND	ND
BS-006PZ	ND	ND	ND	ND	**59 ± 59**	**58 ± 30**	ND	**27**	**820**	ND	**97**	78	**26**	ND	60	ND	3.1	ND	ND
RI Project Screening Goal					15	11.3		5				1,000			100				5,000
ARAR									4 (a)	5 (a,b)	50 (b)		5 (b)				50 (a)	2 (a)	

PA/SI = Preliminary Assessment/Site Inspection
RI = Remedial Investigation
* = Total concentrations in unfiltered samples
USEPA = United States Environmental Protection Agency
µg/l = Micrograms per liter
pCi/l = PicoCuries per liter
WTPH-D = Washington Total Petroleum Hydrocarbons - diesel
ND = Not detected above laboratory method reporting limit
ARAR = Applicable or relevant and appropriate requirement for constituents detected during the PA/SI that were not detected during the RI.
(a) = Federal Primary Maximum Contaminant Level (MCL)
(b) = Model Toxics Control Act Method A Table Value
Shaded cells indicate a detection above the associated RI project screening goal or ARAR.

<u>Constituent Abbreviations</u>

Sb = Antimony
As = Arsenic
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper
Pb = Lead
Hg = Mercury
Ni = Nickel
Se = Selenium
Ag = Silver
Tl = Thallium
Zn = Zinc

One semivolatile organic compound (SVOC), di-n-butylphthalate, was detected in all but one of the soil samples collected during the PA/SI. The presence of di-n-butylphthalate was attributed to possible laboratory contamination of the samples. Total petroleum hydrocarbon (TPH) contamination was detected at a concentration exceeding the associated MTCA Method A Cleanup Level in one soil sample, collected from 2.0 to 3.5 feet bgs in boring BS-003BH. Beryllium concentrations detected in all of the soil samples exceeded the MTCA Method B Cancer Formula Value. In addition, gross alpha and gross beta radiation were detected in approximately half of the soil samples collected. No regulatory standards have been established for gross alpha or gross beta radiation in soil.

Constituents detected in groundwater at concentrations above MTCA Method A Cleanup Levels, Federal MCLs, and/or site-specific background concentrations include gross alpha radiation, gross beta radiation, arsenic, beryllium, chromium, lead, nickel, and thallium. The PA/SI groundwater samples submitted for metals analysis were unfiltered.

2.4.2.5 Conclusions and Recommendations of the PA/SI Report

The PA/SI Report recommended further investigation at the IRP site to determine the source and areal extent of TPH detected in soil and gross alpha and gross beta radiation detected in soil and groundwater. The PA/SI Report also noted that State or Federal regulatory standards were exceeded for several trace metals in soil and/or groundwater, but concentrations of those metals did not exceed site-specific background concentrations, with the exception of beryllium in groundwater.

2.4.3 Phase I Remedial Investigation

This section summarizes the Phase I RI findings at the Seattle ANGS, including information regarding background soil and groundwater quality and site-characterization results for the IRP site. The scope and results of the Phase I RI are described in detail in ERM (1998a).

2.4.3.1 Scope of Work

Field work for the Phase I RI was performed between September 1996 and July 1997. The Phase I RI included a focused investigation of the IRP site, as well as a general sitewide investigation. The field work consisted of a Geoprobe groundwater investigation; collection of surface soil and storm sewer catch basin samples; collection of subsurface soil samples from soil borings; installation and quarterly sampling of groundwater monitoring wells; and aquifer slug testing.

2.4.3.2 Geoprobe Groundwater Investigation Results

Constituents detected in the Geoprobe groundwater samples are summarized on Table 2-3 and presented on Figure 2-5. Benzene and TCE were each detected in two separate groundwater samples collected in the southern portion of the Station, at concentrations that exceed the MTCA Method A Cleanup Level for these compounds (5 µg/l). No other constituents were detected in the Geoprobe groundwater samples at concentrations above PSGs.

2.4.3.3 Surface Soil Sampling Results

Constituents detected in surface soil samples are summarized on Table 2-4 and presented on Figure 2-6. Gross alpha radiation concentrations detected in three samples exceeded the site-specific mean background concentration of 9.96 picoCuries per gram (pCi/g).

The gross beta radiation concentration detected in one sample exceeded the site-specific mean background concentration of 16.1 pCi/g. No regulatory standards have been established for gross alpha or gross beta radiation in soil.

2.4.3.4 Storm Sewer Catch Basin Sampling Results

Constituents detected in storm sewer catch basin samples are summarized on Table 2-5 and presented on Figure 2-7. The catch basin samples consisted of a mixture of sediment and water, and were analyzed as a liquid matrix due to the consistency of the samples. Acetone, p-isopropyltoluene, toluene, radionuclides, and trace metals were detected in the catch basin samples.

The Seattle ANGS does not have or require a storm water permit, and there are no specific regulatory criteria governing the quality of water or sediment present in the Station's storm sewer system. Consequently, no PSGs were developed for constituents detected in catch basin samples. However, based on the catch basin sample analytical results, the storm sewer system does not appear to be a significant pathway for off-site transport of contaminants. Additionally, no potential sources of the constituents detected in the catch basin samples have been identified at the Station.

TABLE 2-3

Constituents Detected in Phase I RI Geoprobe Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Benzene	Toluene	Ethylbenzene	Total Xylenes	Cis-1,2-Dichloroethene	1,2-Dichloroethane	1,1,1-Trichloroethane	Trichloroethene
GP-2	10/8/96	ND	ND	ND	ND	2	ND	ND	3.7
GP-3	10/8/96	**7.6**	ND	ND	ND	ND	2.4	ND	ND
GP-4	10/8/96	ND	ND	ND	ND	2	ND	ND	**17**
GP-5	10/8/96	2.7	1.6	9.9	ND	3.9	ND	ND	4.1
GP-15	10/9/96	ND	ND	ND	ND	5	ND	ND	ND
GP-22	10/9/96	ND	ND	ND	7	ND	ND	2	ND
Project Screening Goal		5	40	30	20	70	5	200	5

All concentrations in micrograms per liter (µg/l).
ND = Not detected above laboratory method reporting limit
Shaded cells indicate a detection above the associated project screening goal
Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.

Phase I
Results

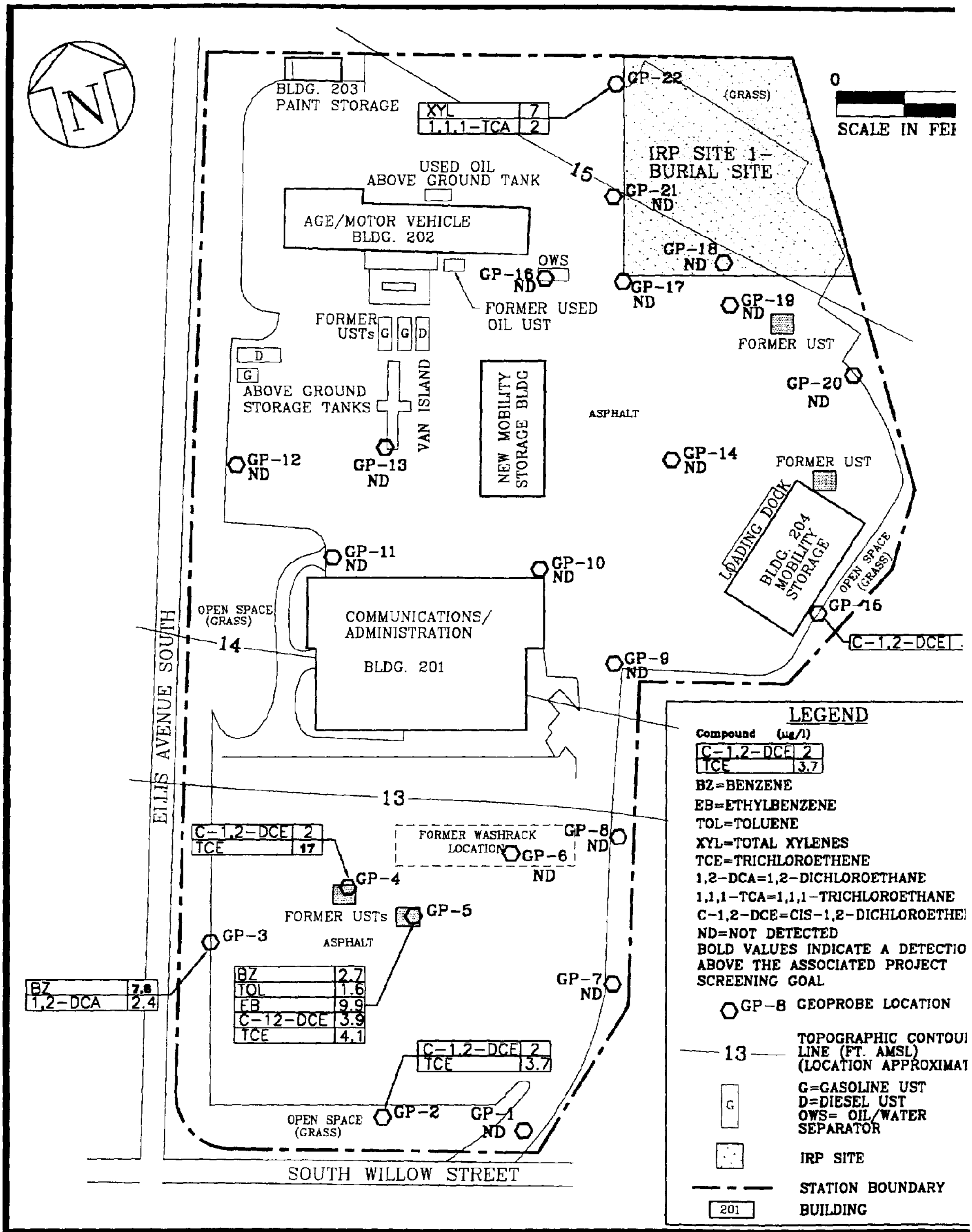

FIGURE 2-5

CONSTITUENTS DETECTED IN
PHASE I RI GEOPROBE
GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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TABLE 2-4

Constituents Detected in Phase I RI Surface Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Depth (ft-bgs)	Total Petroleum Hydrocarbons (mg/kg)			Radionuclides (pCi/g)							
			Gasoline	Diesel	Heavy Oil	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)
SS-01	10/17/96	0.5	ND	ND	ND	7.4	4.8	**16.6**	4.3	0.48	0.20	0.82	0.48
SS-02	10/17/96	0.5	ND	ND	ND	6.1	4.6	13.2	4.0	0.57	0.23	0.57	0.42
SS-03	10/17/96	0.5	23	63	ND	**10.5**	5.3	14.7	4.2	0.44	0.20	0.23	0.39
SS-04	10/17/96	0.5	ND	ND	ND	**10.3**	5.5	13	4.1	0.54	0.19	0.59	0.41
SS-05	10/17/96	0.5	ND	ND	ND	7.3	5.0	14.6	4.2	0.53	0.22	0.64	0.41
SS-06	10/17/96	0.5	ND	ND	ND	4	4.2	9	3.9	0.23	0.17	0.48	0.48
SS-06 (dup)	10/17/96	0.5	ND	ND	ND	3.4	4.2	8.5	3.8	0.29	0.17	0.7	0.43
SS-07	10/17/96	0.5	ND	70	ND	3	4.7	13.1	4.1	0.44	0.20	0.54	0.44
SS-08	10/17/96	0.5	ND	ND	102	7.5	4.9	8.9	3.7	0.39	0.19	0.83	0.45
SS-09	10/17/96	0.5	ND	66	110	**11.9**	5.9	12.9	3.9	0.65	0.17	0.71	0.78
SS-10	10/17/96	0.5	35	ND	ND	6.5	4.6	14.3	4.0	0.65	0.23	0.42	0.57
Project Screening Goal			100	200	200	9.96		16.1		0.77		0.93	

ft-bgs = Feet below ground surface
dup = Duplicate sample
mg/kg = Milligrams per kilogram
pCi/g = PicoCuries per gram
+/- = Margin of error (pCi/g)
ND = Not detected above laboratory method reporting limit
Shaded cells indicate a detection above the associated project screening goal

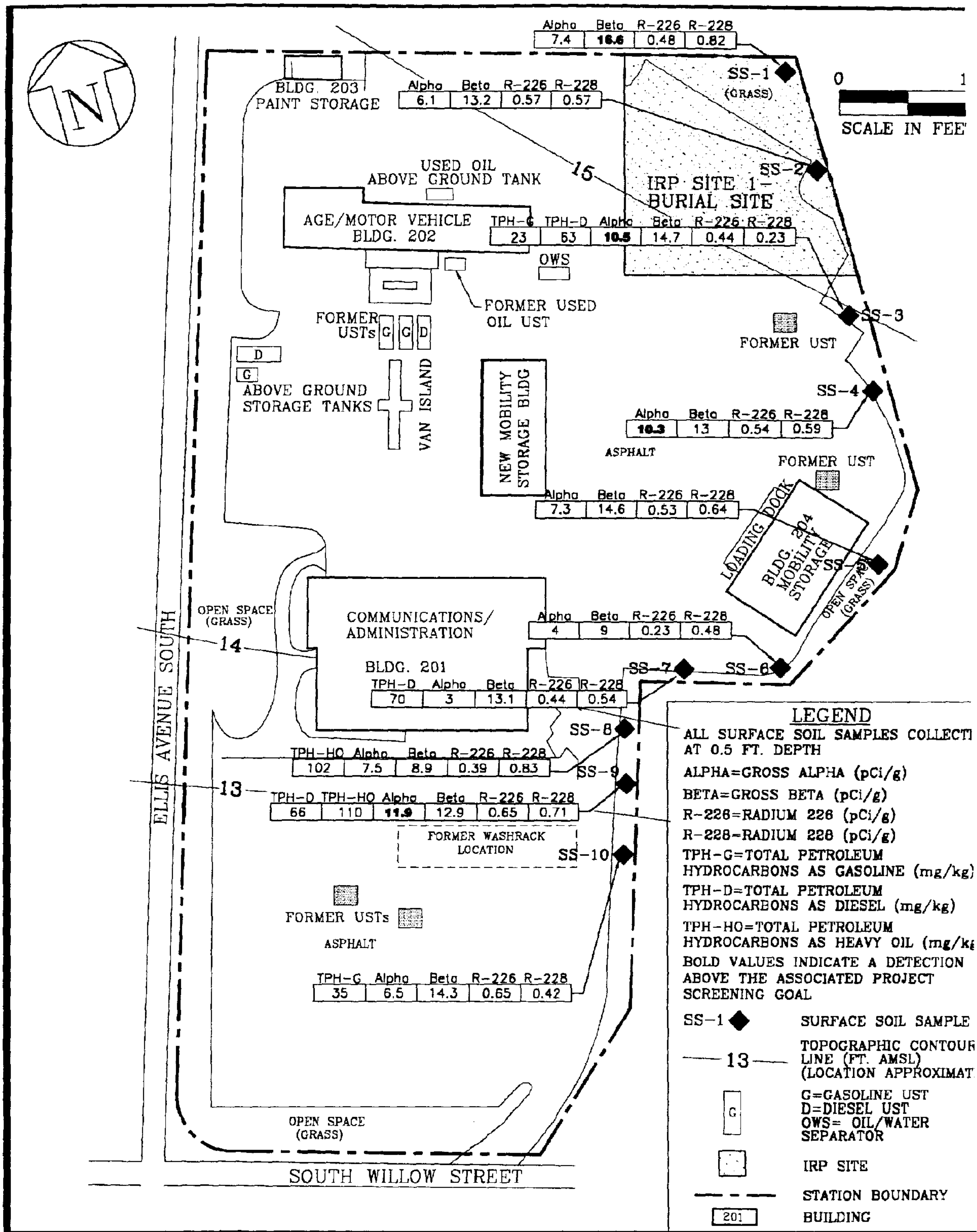

FIGURE 2-6

CONSTITUENTS DETECTED IN PHASE I RI
SURFACE SOIL SAMPLES

143rd CCSQ, Seattle ANGS
Seattle, Washington

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TABLE 2-5

Constituents Detected in Phase I RI Storm Sewer Catch Basin Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	VOCs (µg/l)			Radionuclides (pCi/l)								Trace Metals (µg/l)						
		Acetone	p-IPT	Toluene	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Antimony	Arsenic	Cadmium	Chromium	Copper	Nickel	Zinc
SW-1	7/11/97	18	2.5	19	18	4.6	17.4	2.9	0.12	0.16	1.01	0.48	310	14	44	87	410	62	1,100
SW-2	7/11/97	ND	ND	ND	29.1	7.6	23.9	4.6	0.06	0.14	0.52	0.60	350	ND	21	29	160	20	340

VOCs = Volatile organic compounds
p-IPT = p-isopropyltoluene
µg/l = Micrograms per liter
pCi/l = PicoCuries per liter
ND = Not detected above laboratory method reporting limit
+/- = Margin of error (pCi/l)

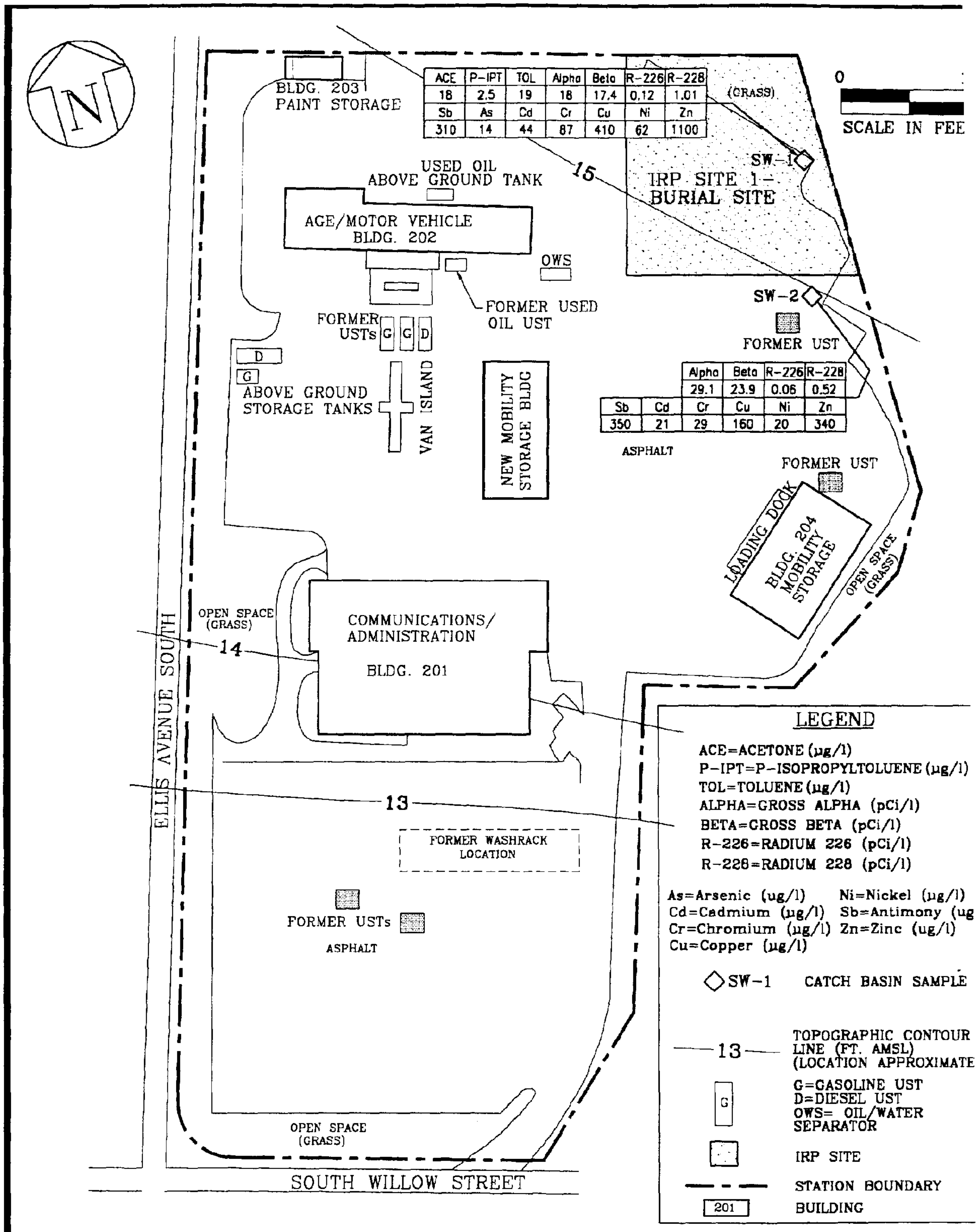

FIGURE 2-7

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CONSTITUENTS DETECTED IN
PHASE I RI STORM SEWER
CATCH BASIN SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

2.4.3.5 Subsurface Soil Sampling Results

Constituents detected in subsurface soil samples are summarized on Tables 2-6 and 2-7. Maximum concentrations of constituents detected in subsurface soil samples are presented on Figures 2-8 and 2-9. The detected concentrations of gross alpha, gross beta, radium-226, and radium-228 in selected subsurface soil samples exceed the site-specific mean background concentrations of these constituents. No other constituents were detected in subsurface soil samples at concentrations above PSGs.

2.4.3.6 Quarterly Groundwater Sampling Results

Constituents detected in groundwater samples collected from monitoring wells during the Phase I RI are summarized on Tables 2-8 through 2-11. Maximum concentrations of constituents detected in these groundwater samples are presented on Figures 2-10 and 2-11.

Two groundwater samples collected from a background well (well BS-004PZ) contained concentrations of tetrachloroethene (PCE) that exceed the MTCA Method A Cleanup Level of 5 μg/l. Selected samples collected from all the monitoring wells contained concentrations of gross beta radiation that exceed the site-specific mean background concentration. Dissolved arsenic was detected in one groundwater sample at a concentration that exceeds the MTCA Method A Cleanup Level of 5 μg/l.

2.4.3.7 Conclusions and Recommendations of the Phase I RI Report

Constituents detected above PSGs in soil at the Seattle ANGS during the Phase I RI include gross alpha, gross beta, radium-226, and radium-228 radionuclides. Constituents detected above PSGs in groundwater include benzene, TCE, PCE, gross beta, and dissolved arsenic. The Phase I RI Report (ERM 1998a) concluded that the radionuclides detected in soil and groundwater reflect naturally occurring background concentrations. The single reported detection of arsenic in one groundwater sample was considered an anomaly, because arsenic was not detected in any of four prior or subsequent groundwater samples collected from the subject monitoring well, and there are no known sources of arsenic at the Station.

TABLE 2-6

Constituents Detected in Phase I RI Background Subsurface Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Sample Depth (ft-bgs)	Radionuclides (pCi/g)								Trace Metals (mg/kg)						
			Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Arsenic	Chromium	Copper	Lead	Nickel	Selenium	Zinc
SB-1	10/15/96	3.0	**11**	5.5	16	4.3	0.29	0.17	0.46	0.68	6.7	14	19	15	10	ND	27
		7.0	8	5.0	15.1	4.1	0.69	0.21	**1.34**	0.68	2.2	8	6	ND	7	0.6	15
		9.0	7.6	5.3	**16.6**	4.2	0.74	0.22	0.69	0.43	1.8	10	7	ND	6	ND	16
SB-2	10/15/96	5.0	6.3	4.9	12.7	4.0	0.71	0.22	0.70	0.38	7	14	20	33	12	2.2	45
		7.0	7.5	4.9	14.5	4.2	**0.88**	0.24	0.77	0.43	2.6	13	17	14	9	1.5	26
		9.0	9.2	5.1	16.1	4.5	0.31	0.16	0.82	0.18	2.5	15	10	11	7	1.4	21
SB-3	10/15/96	3.0	**12.8**	5.9	15.7	4.2	0.76	0.24	0.87	0.42	8.7	17	15	20	14	2.8	30
		7.0	8.1	5.3	16.0	4.1	0.66	0.23	0.38	0.40	0.8	10	8	6	6	ND	14
		9.0	6.8	5.0	15.3	4.1	0.71	0.23	0.76	0.48	2.7	8	7	ND	7	ND	19
95% UCL Mean Concentration			9.96		16.1		0.77		0.93		5.59	14.2	15.8	18.2	10.5	1.66	30.1
Project Screening Goal			9.96		16.1		0.77		0.93		20	100	2,960	250	1,600	400	24,000

RI = Remedial Investigation
mg/kg = Milligrams per kilogram
pCi/g = PicoCuries per gram
ND = Not detected above laboratory method reporting limit
ft-bgs = Feet below ground surface
+/- = Margin of error (pCi/g)
UCL = Upper confidence limit
Shaded cells indicate a detection above the associated project screening goal.
Note: The 95% UCL mean concentration calculation included all RI background samples. For samples that were "ND" for a given constituent, a value equal to one-half of the associated method reporting limit was used in the 95% UCL mean concentration calculation (per WAC 173-340-708).

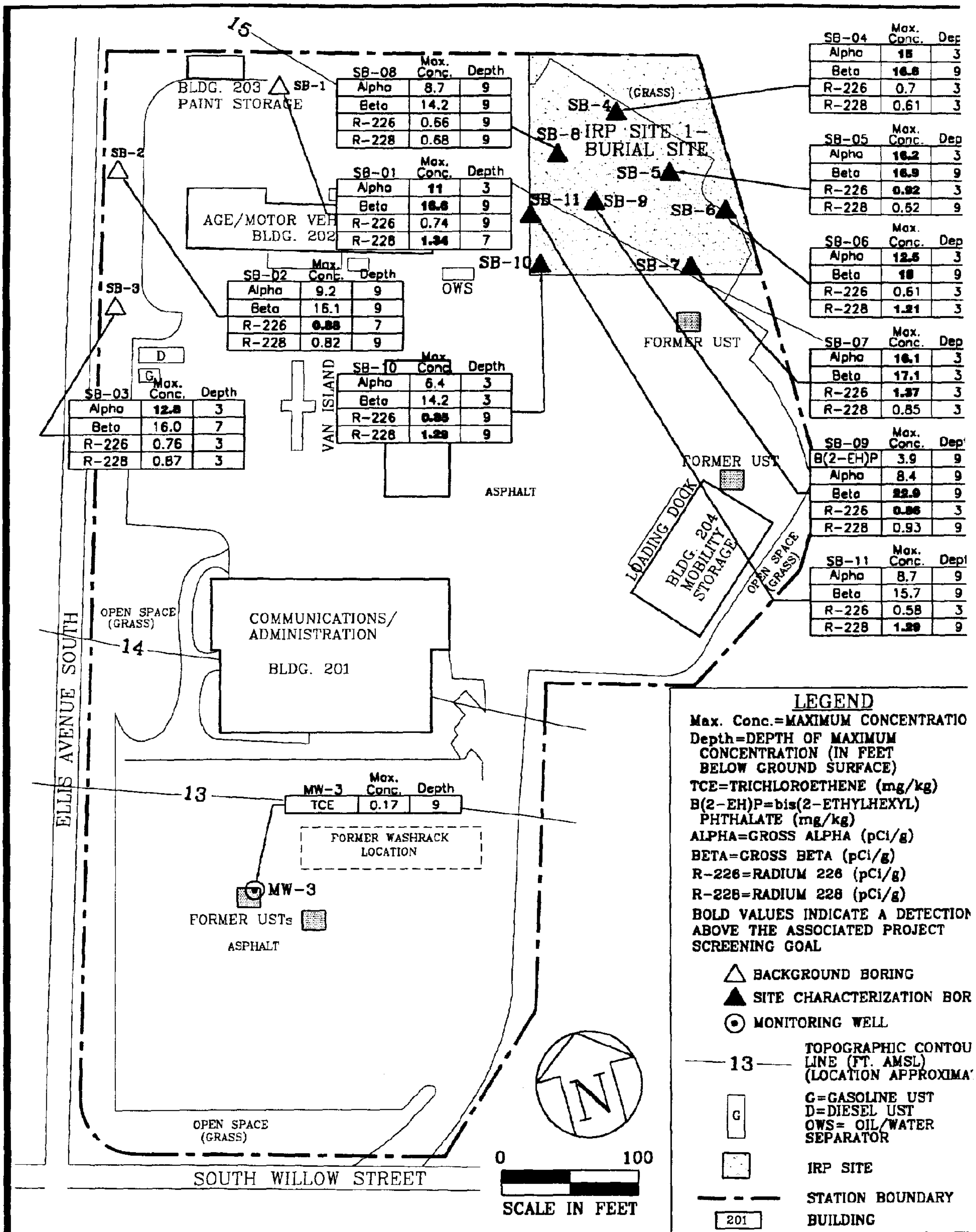
TABLE 2-7

Constituents Detected in Phase I RI Site-Characterization Subsurface Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Depth (ft-bgs)	VOCs (µg/kg)	SVOCs (µg/kg)	Radionuclides (pCi/g)								Trace Metals (mg/kg)							
			TCE	B(2-EH)P	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Selenium	Zinc
SB-04	10/15/96	3	NA	ND	**15**	6.1	14.7	4.0	0.7	0.24	0.61	0.39	11	0.8	16	35	110	16	1.5	100
SB-04	10/15/96	9	NA	ND	6.7	4.7	**16.6**	4.2	0.62	0.22	0.13	0.58	4.8	ND	17	23	19	10	1.4	39
SB-05	10/15/96	3	NA	ND	**16.2**	6.4	15.6	4.2	**0.92**	0.25	0.35	0.57	8.2	ND	14	26	45	12	1.4	47
SB-05	10/15/96	9	NA	ND	**12.4**	6.0	**16.9**	4.2	0.33	0.17	0.62	0.52	5.4	ND	19	25	18	24	1.5	40
SB-06	10/15/96	3	NA	ND	**12.5**	5.8	13.4	4.1	0.61	0.22	**1.21**	0.73	3.1	ND	16	16	10	4	0.8	10
SB-06 (dup)	10/15/96	3	NA	ND	**13.1**	6.0	15.5	4.2	0.48	0.20	0.76	0.57	NA	NA	NA	NA	NA	NA	NA	NA
SB-06	10/15/96	9	NA	ND	6.7	5.4	**18**	4.4	0.45	0.19	0.44	0.62	ND	ND	9	5	8	4	ND	14
SB-06 (dup)	10/15/96	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.7	ND	15	9	11	7	ND	19
SB-07	10/15/96	3	NA	ND	**16.1**	6.4	**17.1**	4.3	**1.37**	0.32	0.85	0.64	13	ND	12	10	19	7	ND	16
SB-07	10/15/96	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	13	6	8	4	ND	15
SB-08	10/16/96	3	NA	ND	5	4.4	11.7	3.9	0.55	0.20	0.57	0.47	11	ND	14	31	64	13	ND	89
SB-08	10/16/96	9	NA	ND	8.7	5.9	14.2	4.2	0.66	0.21	0.68	0.44	4.5	ND	16	26	17	12	ND	38
SB-09	10/16/96	3	NA	ND	8.2	5.2	14	4.2	**0.86**	0.24	0.53	0.42	12	ND	13	21	76	10	ND	42
SB-09 (dup)	10/16/96	3	NA	ND	**10.5**	5.5	15.7	4.2	0.63	0.23	0.56	0.47	20	ND	16	28	250	14	ND	210
SB-09	10/16/96	9	NA	3,900	8.4	5.1	**22.9**	4.7	0.64	0.21	0.93	0.47	5.3	ND	16	18	13	16	ND	49
SB-10	10/16/96	3	NA	ND	6.4	4.9	14.2	4.1	0.76	0.26	**1.01**	0.45	4.3	ND	10	11	11	7	ND	19
SB-10	10/16/96	9	NA	ND	5.8	4.5	13.4	3.9	**0.85**	0.26	**1.29**	0.52	4.6	ND	11	15	18	7	ND	22
SB-11	10/16/96	3	NA	ND	4.9	4.5	14.7	4.1	0.58	0.21	0.54	0.48	4	ND	11	18	15	7	ND	28
SB-11	10/16/96	9	NA	ND	8.7	5.8	15.7	4.3	0.47	0.21	**1.29**	0.51	6.9	ND	18	22	20	20	ND	43
MW-3	10/17/96	5	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-3	10/17/96	9	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Project Screening Goal			500	71,400	9.96		16.1		0.77		0.93		20	2	100	2,960	250	1,600	400	24,000

VOCs = Volatile organic compounds
SVOCs = Semivolatile organic compounds
TCE = Trichloroethene
B(2-EH)P = Bis(2-ethylhexyl)phthalate
mg/kg = Milligrams per kilogram
pCi/g = PicoCuries per gram
µg/kg = Micrograms per kilogram
Shaded cells indicate a detection above the associated project screening goal

ft-bgs = Feet below ground surface
ND = Not detected above laboratory method reporting limit
NA = Not analyzed
+/- = Margin of error (pCi/g)
dup = Duplicate sample



SB-08	Max. Conc.	Depth
Alpha	8.7	9
Beta	14.2	9
R-226	0.66	9
R-228	0.68	9

SB-01	Max. Conc.	Depth
Alpha	**11**	3
Beta	**16.6**	9
R-226	0.74	9
R-228	**1.34**	7

SB-02	Max. Conc.	Depth
Alpha	9.2	9
Beta	16.1	9
R-226	**0.88**	7
R-228	0.82	9

SB-10	Max. Conc.	Depth
Alpha	6.4	3
Beta	14.2	3
R-226	**0.85**	9
R-228	**1.29**	9

SB-03	Max. Conc.	Depth
Alpha	**12.8**	3
Beta	16.0	7
R-226	0.76	3
R-228	0.87	3

SB-04	Max. Conc.	Dep
Alpha	**15**	3
Beta	**16.6**	9
R-226	0.7	3
R-228	0.61	3

SB-05	Max. Conc.	Dep
Alpha	**16.2**	3
Beta	**16.9**	9
R-226	**0.92**	3
R-228	0.52	9

SB-06	Max. Conc.	Dep
Alpha	**12.5**	3
Beta	**18**	9
R-226	0.61	3
R-228	**1.21**	3

SB-07	Max. Conc.	Dep
Alpha	**16.1**	3
Beta	**17.1**	3
R-226	**1.37**	3
R-228	0.85	3

SB-09	Max. Conc.	Dep
B(2-EH)P	3.9	9
Alpha	8.4	9
Beta	**22.9**	9
R-226	**0.86**	3
R-228	0.93	9

SB-11	Max. Conc.	Dep
Alpha	8.7	9
Beta	15.7	9
R-226	0.58	3
R-228	**1.29**	9

MW-3	Max. Conc.	Depth
TCE	0.17	9

FIGURE 2-8

MAXIMUM CONCENTRATIONS OF ORGANIC COMPOUNDS AND RADIONUCLIDES DETECTED IN PHASE I RI SUBSURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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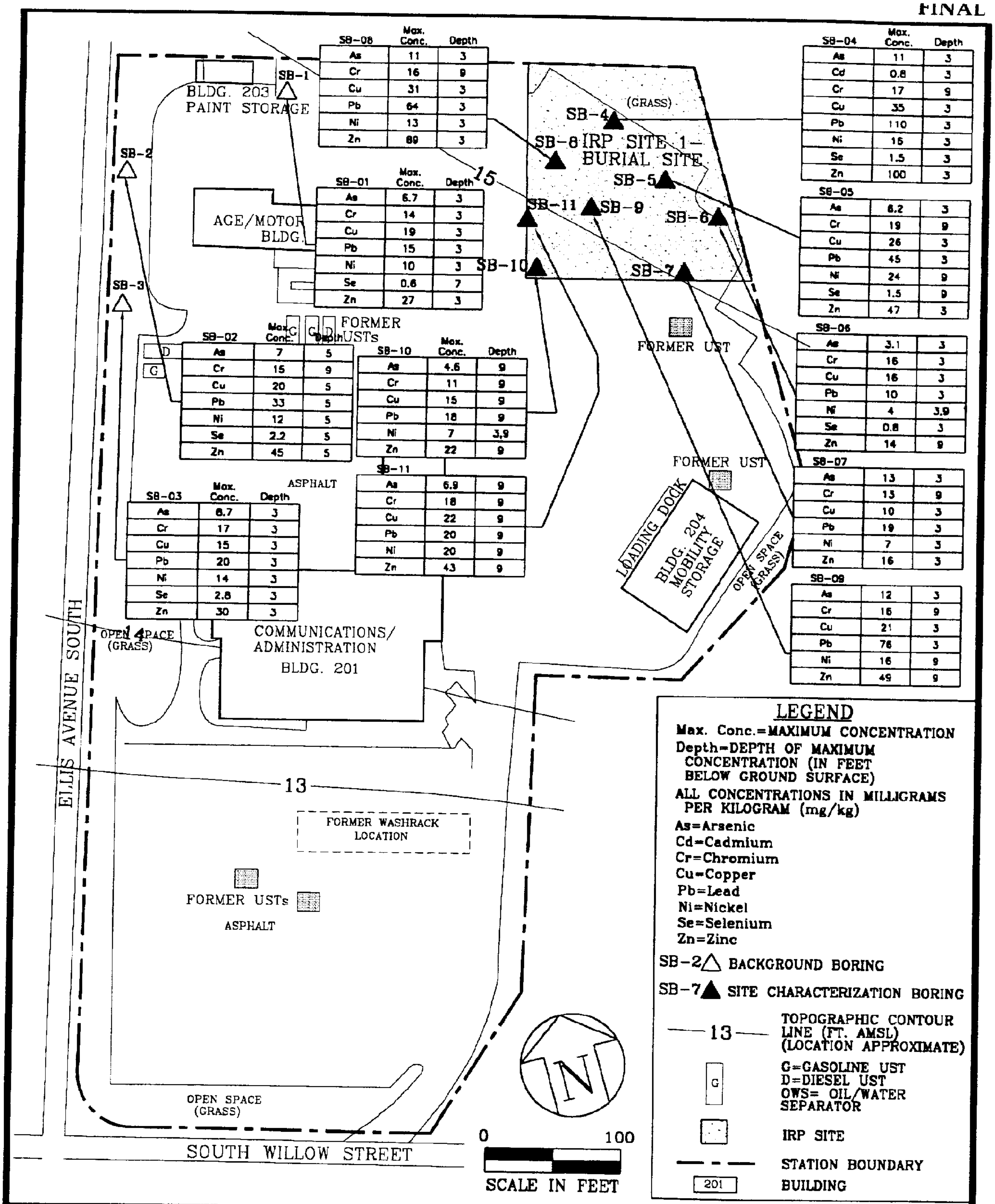

SB-08	Max. Conc.	Depth
As	11	3
Cr	16	9
Cu	31	3
Pb	64	3
Ni	13	3
Zn	89	3

SB-04	Max. Conc.	Depth
As	11	3
Cd	0.8	3
Cr	17	9
Cu	35	3
Pb	110	3
Ni	16	3
Se	1.5	3
Zn	100	3

SB-01	Max. Conc.	Depth
As	6.7	3
Cr	14	3
Cu	19	3
Pb	15	3
Ni	10	3
Se	0.6	7
Zn	27	3

SB-05		
As	6.2	3
Cr	19	9
Cu	26	3
Pb	45	3
Ni	24	9
Se	1.5	9
Zn	47	3

SB-06		
As	3.1	3
Cr	16	3
Cu	16	3
Pb	10	3
Ni	4	3,9
Se	0.8	3
Zn	14	9

SB-02	Max. Conc.	Depth
As	7	5
Cr	15	9
Cu	20	5
Pb	33	5
Ni	12	5
Se	2.2	5
Zn	45	5

SB-10	Max. Conc.	Depth
As	4.6	9
Cr	11	9
Cu	15	9
Pb	18	9
Ni	7	3,9
Zn	22	9

SB-07		
As	13	3
Cr	13	9
Cu	10	3
Pb	19	3
Ni	7	3
Zn	16	3

SB-11		
As	6.9	9
Cr	18	9
Cu	22	9
Pb	20	9
Ni	20	9
Zn	43	9

SB-03	Max. Conc.	Depth
As	6.7	3
Cr	17	3
Cu	15	3
Pb	20	3
Ni	14	3
Se	2.8	3
Zn	30	3

SB-09		
As	12	3
Cr	16	9
Cu	21	3
Pb	76	3
Ni	16	9
Zn	49	9

LEGEND

Max. Conc.=MAXIMUM CONCENTRATION
Depth=DEPTH OF MAXIMUM CONCENTRATION (IN FEET BELOW GROUND SURFACE)
ALL CONCENTRATIONS IN MILLIGRAMS PER KILOGRAM (mg/kg)
As=Arsenic
Cd=Cadmium
Cr=Chromium
Cu=Copper
Pb=Lead
Ni=Nickel
Se=Selenium
Zn=Zinc
SB-2 △ BACKGROUND BORING
SB-7 ▲ SITE CHARACTERIZATION BORING
—13— TOPOGRAPHIC CONTOUR LINE (FT. AMSL) (LOCATION APPROXIMATE)
G=GASOLINE UST
D=DIESEL UST
OWS= OIL/WATER SEPARATOR
IRP SITE
STATION BOUNDARY
201 BUILDING

FIGURE 2-9

MAXIMUM CONCENTRATIONS OF METALS DETECTED IN PHASE I RI SUBSURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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TABLE 2-8

Constituents Detected in Phase I RI Background Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Volatile Organic Compounds (µg/l)				Radionuclides (pCi/l)								Trace Metals* (µg/l)		
		1,1-DCA	PCE	1,1,1-TCA	Toluene	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Copper	Nickel	Zinc
BS-004PZ	9/17/96	0.3	3.8	3.7	(ND)	2.2	1.7	**13.2**	2.1	0.2	0.18	-0.08	0.51	ND	ND	ND
	9/17/96 (dup)	0.3	3.8	3.8	(ND)	0.2	1.1	**11.7**	2	0.19	0.15	-0.6	0.45	ND	ND	ND
	1/14/97	ND	**5.1**	2.4	ND	2.1	1.5	9.9	1.8	0.02	0.12	0.25	0.4	ND	ND	61
	4/11/97	ND	**17**	3.3	ND	1.3	1.3	6.8	1.7	0.04	0.12	0.29	0.38	5	ND	(ND)
	7/10/97	ND	(ND)	1.8	ND	0.9	1.2	8.6	1.8	0.05	0.13	0.22	0.41	6	ND	(ND)
MW-1	10/18/96	ND	ND	ND	ND	0.5	1	8.1	1.8	0.27	0.18	0.08	0.44	ND	ND	(ND)
	12/17/96	ND	ND	ND	ND	3.9	1.9	**12.7**	2.1	0.18	0.18	0.2	0.37	ND	ND	ND
	1/14/97	ND	ND	ND	1.1	-0.09	0.84	10.4	1.9	0.35	0.24	0.31	0.44	ND	8	(ND)
	4/11/97	ND	ND	ND	ND	0	1.1	1.03	1.9	0.22	0.15	0.02	0.37	ND	8	61
	7/11/97	ND	ND	ND	ND	-0.3	1	9	1.8	0.19	0.16	0.2	0.6	19	13	(ND)
95% UCL Mean Concentration		0.513	7.33	2.63	1.04	2.09		11.3		0.236		0.258		8.06	9.66	51
Project Screening Goal		800	5	200	40	15		11.3		3		2		1,000	100	5,000

RI = Remedial Investigation

* = Dissolved concentrations in filtered samples

ND = Not detected above laboratory method reporting limit

(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).

pCi/l = PicoCuries per liter

µg/l = Micrograms per liter

+/- = Margin of error (pCi/l)

dup = Duplicate sample

UCL = Upper confidence limit

Shaded cells indicate a detection above the associated project screening goal.

Note: The 95% UCL mean concentration calculation included all RI background samples. For samples that were "ND" for a given constituent, a value equal to one-half of the associated method reporting limit was used in the calculation (per WAC 173-340-708).

Constituent Abbreviations

1,1-DCA = 1,1-Dichloroethane

PCE = Tetrachloroethene

1,1,1-TCA = 1,1,1-Trichloroethane

TABLE 2-9

Organic Constituents Detected in Phase I RI Site-Characterization Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Acetone	Cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene	Tetrachloroethene	Trichloroethene
BS-005PZ	9/17/96	ND	ND	0.2	ND	ND
BS-005PZ	7/11/97	ND	ND	ND	4.7	ND
BS-006PZ	9/17/96	ND	ND	0.2	ND	ND
MW-03	10/18/96	18	ND	ND	ND	ND
MW-03	10/18/96 (dup)	20	ND	ND	ND	ND
MW-04	10/18/96	11	ND	ND	ND	3.9
MW-04	12/17/96	ND	ND	ND	ND	2.7
MW-04	1/14/97	ND	ND	ND	ND	3.4
MW-04	4/11/97	ND	ND	ND	ND	3.2
MW-04	7/11/97	ND	ND	ND	ND	2.8
MW-05	10/18/96	ND	5.6	ND	ND	ND
MW-05	12/17/96	ND	4.9	ND	ND	ND
MW-05	1/14/97	ND	2.7	ND	ND	ND
MW-05	4/11/97	ND	1.4	ND	ND	ND
MW-05	4/11/97 (dup)	ND	1.6	ND	ND	ND
MW-05	7/10/97	ND	3.5	ND	(ND)	2.1
MW-05	7/10/97 (dup)	ND	2.8	ND	ND	ND
	Project Screening Goal	800	70	0.507	5	5

All concentrations in micrograms per liter (μg/l)
ND = Not detected above laboratory method reporting limit.
(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).
dup = Duplicate sample
Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.

TABLE 2-10

Radionuclides Detected in Phase I RI Site-Characterization Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)
BS-005PZ	9/17/96	0	1.7	**20**	3.0	0.07	0.15	0.23	0.49
	1/15/97	2.7	2.2	**19.3**	2.7	0.11	0.16	0.01	0.42
	4/10/97	-0.14	1.0	**14.2**	2.2	0.11	0.12	0.43	0.44
	7/10/97	0.6	1.6	**13.8**	2.4	0.15	0.20	NA	NA
BS-006PZ	9/17/96	0.1	1.6	10.3	2.5	0.04	0.13	0.29	0.45
	1/14/97	-0.1	1.3	**11.5**	2.0	0.14	0.18	0.14	0.36
	4/10/97	0.1	1.7	10.5	2.1	0.131	0.97	0.07	0.45
	7/10/97	0.4	1.5	10.3	2.3	0.14	0.14	0.19	0.44
MW-02	10/18/96	0.4	1.3	**8.8**	2.1	0.04	0.15	-0.2	0.43
	12/17/96	3.7	2.0	**12.8**	2.1	0.11	0.16	0.1	0.41
	1/15/97	0.5	1.3	**11.5**	2.0	0.04	0.11	0.07	0.35
	1/15/97 (dup)	0.4	1.2	**11.5**	2.0	0.08	0.13	0.14	0.42
	4/10/97	0.8	1.3	10.8	1.9	0.04	0.14	0.11	0.42
	7/10/97	-0.1	1.3	11.1	2.5	0.11	0.13	0.6	0.42
MW-03	10/18/96	-0.2	1.4	8.3	1.8	0.09	0.17	1.43	0.47
	10/18/96 (dup)	7.8	2.7	8.9	1.8	0.15	0.15	1.88	0.47
	12/17/96	4	2.8	8.9	2.6	0.12	0.17	0.36	0.42
	12/17/96 (dup)	1.8	1.9	9	2.1	0.023	0.10	-0.15	0.40
	1/15/97	-0.2	1.0	8.2	1.8	0.21	0.17	0.12	0.51
	4/10/97	1.4	1.6	**14.8**	2.2	0.13	0.13	0.26	0.44
	7/10/97	0.3	1.7	**17.3**	2.9	0.16	0.15	0.78	0.61
MW-04	10/18/96	10.8	3.9	**17.2**	3.0	0.2	0.17	0.65	0.40
	12/17/96	4.8	2.8	**19.1**	3.1	0.05	0.13	0.09	0.44
	1/14/97	0.3	1.5	**16.4**	2.5	0.1	0.19	-0.19	0.44
	4/10/97	0.2	1.2	**12.9**	2.1	0.11	0.13	0.26	0.37
	7/10/97	-0.67	0.7	11.1	2.1	0.101	0.10	0.15	0.44
MW-05	10/18/96	-0.1	2.1	**12.3**	2.9	0.5	0.26	1.52	0.44
	12/17/96	5.2	3.4	**13.3**	3.2	0.13	0.13	0.35	0.37
	1/14/97	1.9	2.8	10.6	3.0	0.21	0.19	0.03	0.43
	4/10/97	1.3	1.7	8.9	2.0	0.16	0.14	-0.4	0.39
	4/10/97 (dup)	0.3	2.1	7.1	2.3	0.16	0.15	0.01	0.35
	7/10/97	-0.4	1.4	9.9	2.4	0.09	0.11	0.53	0.47
Project Screening Goal		15		11.3		3		2	

All concentrations in picoCuries per liter (pCi/l)
dup = Duplicate sample
NA = Not analyzed
+/- = Margin of error (pCi/l)
Shaded cells indicate a detection above the associated project screening goal

TABLE 2-11

Trace Metals Detected in Phase I RI Site-Characterization Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Arsenic	Copper	Nickel	Zinc
BS-005PZ	9/17/96	ND	ND	60	10
	1/15/97	ND	ND	15	(ND)
	4/11/97	ND	ND	9	(ND)
	7/11/97	ND	ND	7	(ND)
BS-006PZ	9/17/96	ND	ND	40	ND
	1/14/97	ND	ND	6	(ND)
	4/11/97	ND	ND	10	(ND)
	7/11/97	ND	8	5	(ND)
MW-02	12/17/96	ND	6	15	(ND)
	1/15/97	ND	10	20	(ND)
	1/15/97 (dup)	ND	11	21	50
	4/10/97	ND	20	16	(ND)
	7/11/97	ND	ND	17	(ND)
MW-03	1/15/97	ND	ND	ND	46
	4/11/97	ND	ND	8	(ND)
	7/11/97	ND	13	ND	(ND)
MW-04	12/17/96	ND	ND	7	(ND)
	1/14/97	ND	ND	7	270
	4/11/97	ND	ND	9	(ND)
MW-05	12/17/96	6	ND	9	(ND)
	1/14/97	ND	ND	10	(ND)
	4/11/97	ND	ND	8	(ND)
	4/11/97 (dup)	ND	ND	7	(ND)
	7/10/97	ND	ND	8	(ND)
	7/10/97 (dup)	ND	ND	8	(ND)
Project Screening Goal		5	1,000	100	5,000

All concentrations in micrograms per liter (µg/l)

Values shown represent dissolved concentrations in filtered samples.

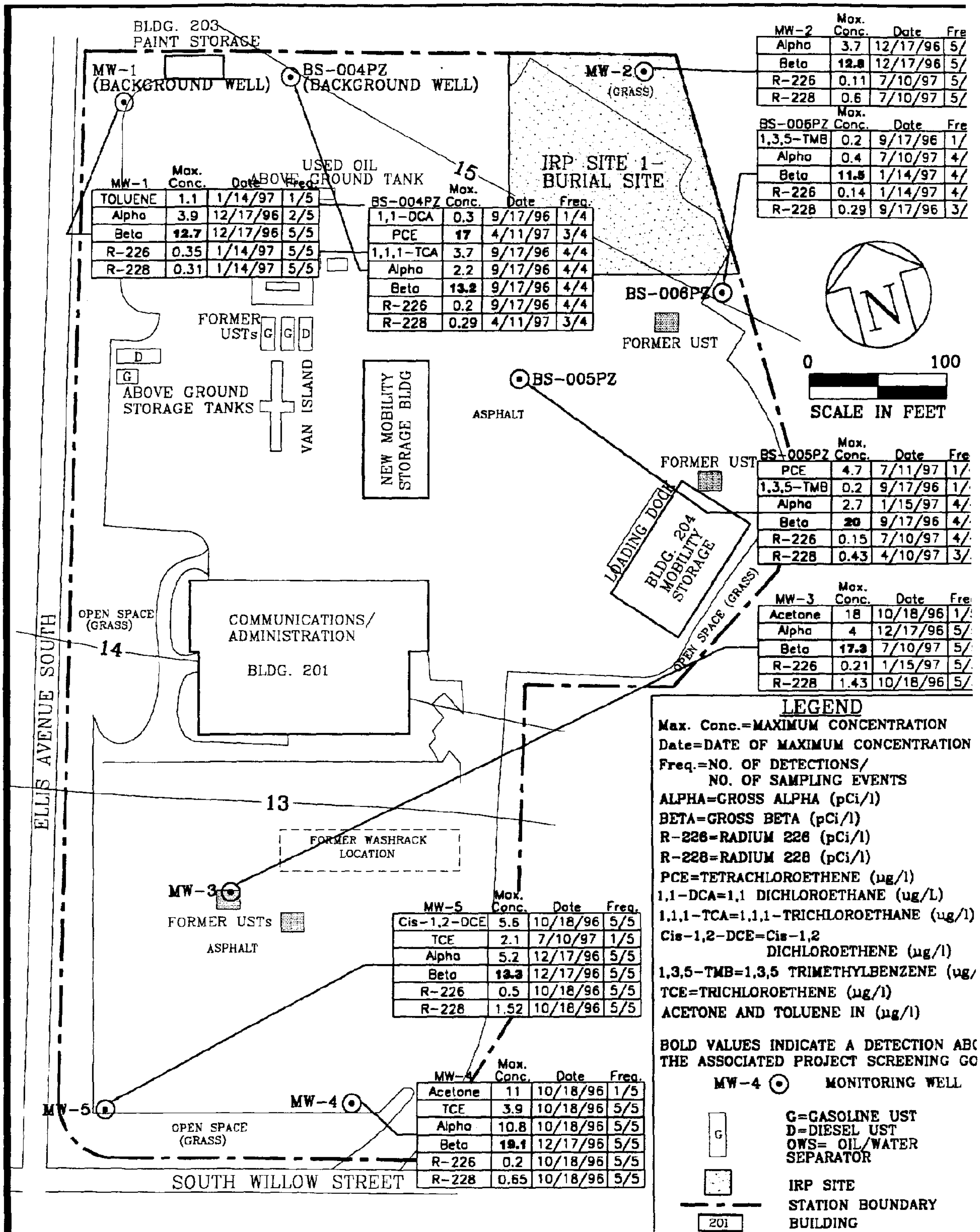
dup = Duplicate sample

ND = Not detected above laboratory method reporting limit

(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).

Shaded cells indicate a detection above the associated project screening goal

Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.



MW-1	Max. Conc.	Date	Freq.
TOLUENE	1.1	1/14/97	1/5
Alpha	3.9	12/17/96	2/5
Beta	**12.7**	12/17/96	5/5
R-226	0.35	1/14/97	5/5
R-228	0.31	1/14/97	5/5

BS-004PZ	Max. Conc.	Date	Freq.
1,1-DCA	0.3	9/17/96	1/4
PCE	**17**	4/11/97	3/4
1,1,1-TCA	3.7	9/17/96	4/4
Alpha	2.2	9/17/96	4/4
Beta	**13.2**	9/17/96	4/4
R-226	0.2	9/17/96	4/4
R-228	0.29	4/11/97	3/4

MW-2	Max. Conc.	Date	Fre
Alpha	3.7	12/17/96	5/
Beta	**12.8**	12/17/96	5/
R-226	0.11	7/10/97	5/
R-228	0.6	7/10/97	5/

BS-006PZ	Max. Conc.	Date	Fre
1,3,5-TMB	0.2	9/17/96	1/
Alpha	0.4	7/10/97	4/
Beta	**11.5**	1/14/97	4/
R-226	0.14	1/14/97	4/
R-228	0.29	9/17/96	3/

BS-005PZ	Max. Conc.	Date	Fre
PCE	4.7	7/11/97	1/
1,3,5-TMB	0.2	9/17/96	1/
Alpha	2.7	1/15/97	4/
Beta	**20**	9/17/96	4/
R-226	0.15	7/10/97	4/
R-228	0.43	4/10/97	3/

MW-3	Max. Conc.	Date	Fre
Acetone	18	10/18/96	1/
Alpha	4	12/17/96	5/
Beta	**17.3**	7/10/97	5/
R-226	0.21	1/15/97	5/
R-228	1.43	10/18/96	5/

MW-5	Max. Conc.	Date	Freq.
Cis-1,2-DCE	5.6	10/18/96	5/5
TCE	2.1	7/10/97	1/5
Alpha	5.2	12/17/96	5/5
Beta	**13.3**	12/17/96	5/5
R-226	0.5	10/18/96	5/5
R-228	1.52	10/18/96	5/5

MW-4	Max. Conc.	Date	Freq.
Acetone	11	10/18/96	1/5
TCE	3.9	10/18/96	5/5
Alpha	10.8	10/18/96	5/5
Beta	**19.1**	12/17/96	5/5
R-226	0.2	10/18/96	5/5
R-228	0.65	10/18/96	5/5

FIGURE 2-10

MAXIMUM CONCENTRATIONS OF ORGANIC COMPOUNDS AND RADIONUCLIDES DETECTED IN PHASE I RI GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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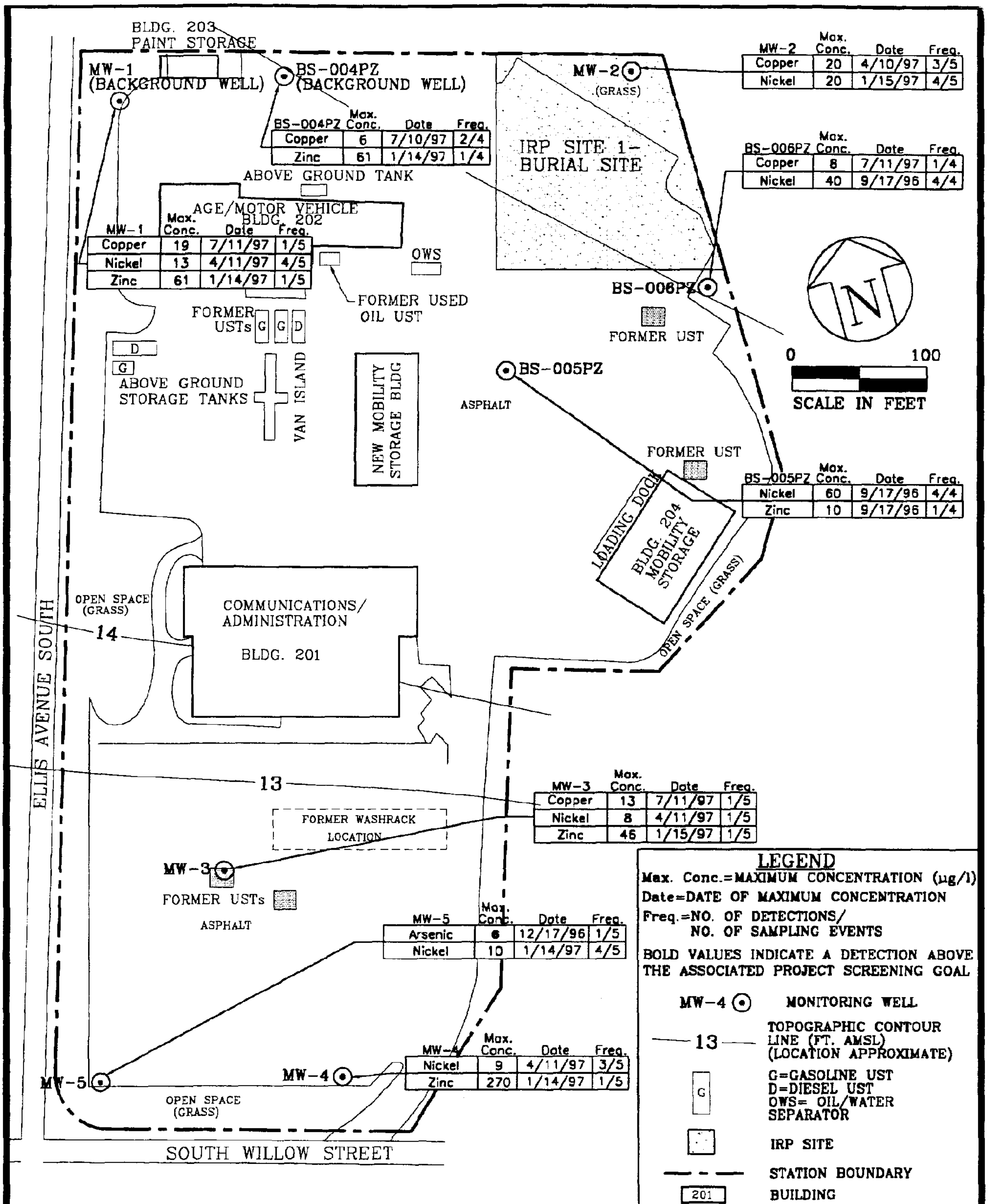

FIGURE 2-11

MAXIMUM CONCENTRATIONS OF
METALS DETECTED IN PHASE I RI
GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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The Phase I RI Report recommended further investigation of the southern and northwest portions of the Station to determine the source and extent of dissolved volatile organic compounds (VOCs) in groundwater. The Phase I RI Report also recommended using the data collected during the additional investigations to refine, as necessary, the preliminary estimates of human health risks obtained from the Phase I baseline risk assessment.

SECTION 3.0

ENVIRONMENTAL SETTING

This section describes the environmental setting at the Seattle ANGS to establish a reference for the work performed during the RI.

3.1 Climate

The climate in the Seattle area is characterized by mild summers and cool winters, with long spring and fall seasons. In winter, the average daily temperature ranges from 37 to 47 degrees Fahrenheit (°F), while in summer the average daily temperature ranges from 55 to 72 °F. The average annual precipitation is 38.84 inches, including 7.4 inches of snow. The greatest percentage of rainfall occurs in the winter months from November to January. The average monthly precipitation ranges from 0.89 inches in July to 6.29 inches in December. The heaviest 24-hour rainfall of 3.74 inches was recorded on 5-6 October 1981. Rainfall intensity, based on a 2-year, 24-hour duration, is 2.0 inches. Free-water surface evaporation in the Seattle area is approximately 25 inches per year, resulting in a net precipitation of 13.84 inches per year. The prevailing wind is from the southwest, and the highest average wind speed of 9.8 miles per hour occurs during March (OpTech 1995).

3.2 Topography

The Seattle ANGS is in King County in the Puget Sound Lowlands physiographic province. The Puget Sound Lowlands is a north-south trending structural and topographic depression bordered on the west by the Olympic Mountains and on the east by the Cascade Range. The Lowlands extend north from the Oregon-Washington state line to the Canadian border.

The terrain at the Station is flat and level, with a surface elevation of approximately 14 feet above mean sea level.

3.3 Geology

A geologic map of the Seattle, Washington area and a generalized stratigraphic column for the Puget Sound area are presented on Figures 3-1 and 3-2, respectively.

The Seattle ANGS is situated in the central portion of the Puget Sound Lowlands, a broad glacial drift plain that is dissected by a network of deep marine embayments. The site is located within the north-south trending Duwamish Valley on the Duwamish Waterway flood plain, a former marine embayment that has been filled with sediment since the end of the last glaciation, referred to locally as the Vashon glaciation. The Duwamish Valley is bounded on the east and west by uplands of glacial drift and bedrock.

Glacial sediment deposits known collectively as the Vashon Drift represent the last major advance and retreat of glacial ice in the Puget Sound area, and commonly overlie a sequence of older glacial and nonglacial sediments throughout the site vicinity. Near the site, at least 75 feet of recent alluvium deposited by the Duwamish River overlies the Vashon Drift deposits.

Alluvial deposits in the Duwamish Valley primarily range from silt through silty sand to fine to medium sand. The alluvial deposits exhibit gradation common to meandering rivers, which typically produce intermittent layering of silts and sands with occasional layers of peat and other organic material deposited in marsh areas.

In the 1910s, much of the Duwamish Valley was raised with fill to accommodate development. The meandering Duwamish River was channelized in its present position during this time. Prior to extensive filling and regrading in the vicinity of the Seattle ANGS between 1917 and 1919, a meander of the Duwamish River flowed along the eastern site boundary. Fill materials in the former channel bed in the vicinity of the Station consist of up to 6 feet of silty sand to fine sand and up to 10 feet of coal ash, clinkers, and brick fragments. Soils below the coal combustion residue consist of fine sand with trace gravel to a depth of at least 35 feet bgs (OpTech 1995).

The subsurface data collected during the PA/SI and RI drilling activities indicate that the near-surface geology at the Seattle ANGS is predominantly composed of two units. The first unit is a silty sand fill material present to a depth of approximately 8 feet bgs. The fill material is

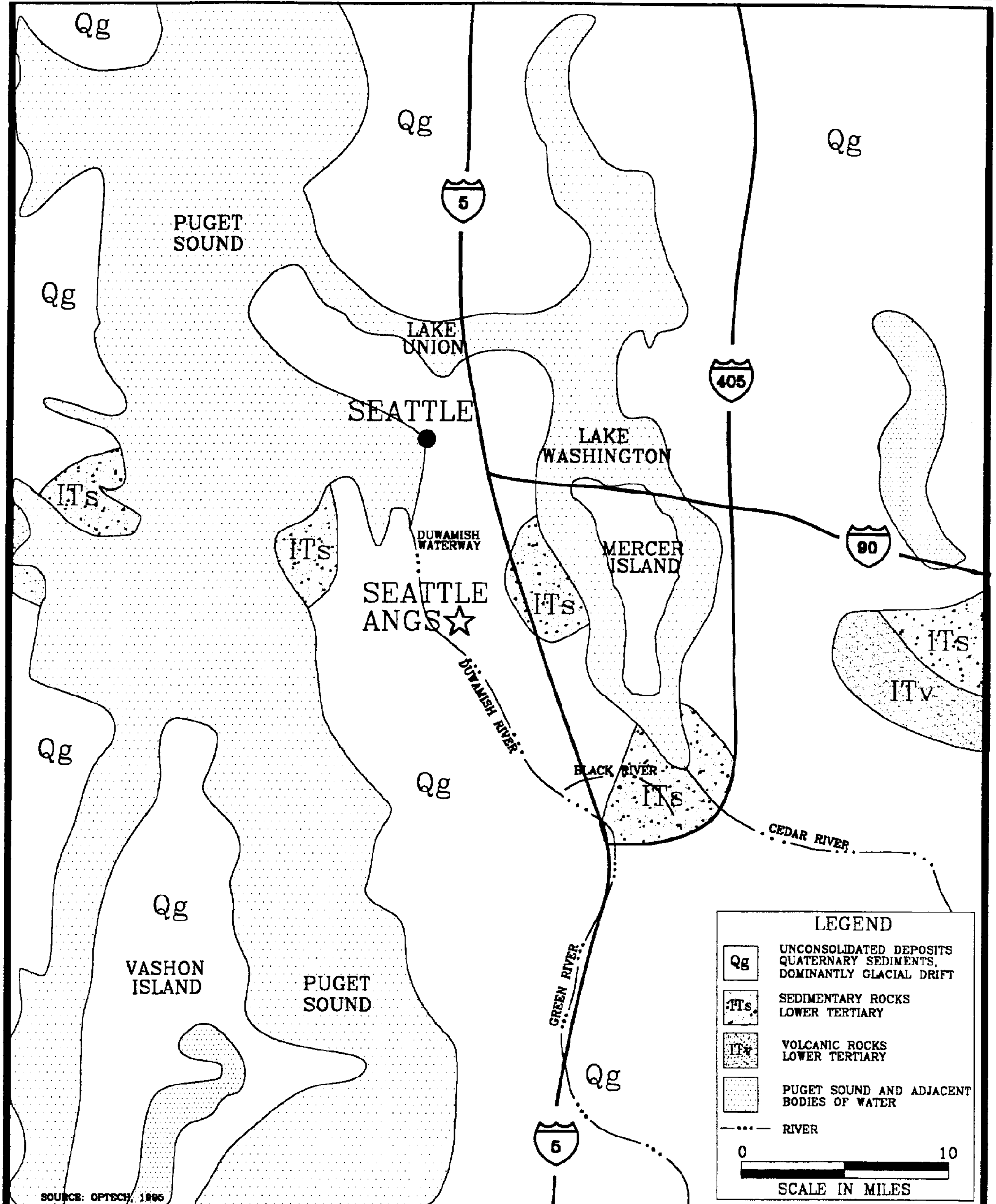

FIGURE 3-1 S:\cad\dwgs\6051\41\60514112	GEOLOGIC MAP OF THE SEATTLE, WASHINGTON AREA 143rd CCSQ, Seattle ANGS Seattle, Washington	ERM

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EPOCH		PUGET LOWLAND SOUTHERN		APPROXIMATE THICKNESS OF SOUTHERN UNITS (FEET)	PUGET LOWLAND NORTHERN			AGE (YEARS)
HOLO-CENE		RECENT ALLUVIUM		75				
PLEISTOCENE	LATE				FRASER DRIFT		SUMAS DRIFT	10,000
							EVERSON GLACIOMARINE DRIFT	11,000
		FRASHER DRIFT	VASHON DRIFT	NA		VASHON DRIFT	VASHON TILL	13,000
							ESPERANCE SAND	
							LAWTON CLAY	
		SEDIMENTS OF THE NONGLACIAL OLYMPIA INTERVAL		NA	SEDIMENTS OF THE NONGLACIAL OLYMPIA INTERVAL			20,000
					POSSESSION DRIFT			28,000 42,000
					WHIDBEY FORMATION (INTERGLACIAL)			90,000
					DOUBLE BLUFF DRIFT			100,000
		SALMON SPRINGS DRIFT	UPPER SALMON SPRINGS GRAVEL AND TILL	NA				250,000
			SILT, PEAT AND ASH	NA				1,000,000
			LOWER SALMON SPRINGS GRAVEL AND TILL	NA				
	EARLY	PUYALLUP FORMATION (INTERGLACIAL)		130				
		STUCK DRIFT		NA				
		ALDERTON FORMATION (INTERGLACIAL)		25				
		ORTING DRIFT		200				2,000,000(?)

SOURCE: OPTECH, 1996

NA – NOT AVAILAB

FIGURE 3–2

GENERALIZED STRATIGRAPHIC COLUMN FOR THE PUGET SOUND LOWLANDS
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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SEA407833

consistent with the descriptions of the material used to raise the Duwamish Valley for development in the 1910s. The second unit consists primarily of well-sorted, fine-grained sand present from approximately 8 feet bgs to the maximum depth explored at the Station during the PA/SI and RI (21.5 feet bgs). Figures 3-3, 3-4, and 3-5 show geologic cross-sections through the Station generated from PA/SI and Phase I RI data.

3.4 Soils

The United States Department of Agriculture classified the soil underlying the Seattle ANGS as unclassified urban land. Urban land is soil that has been modified by the disturbance of the natural layers with additions of fill material several feet thick to accommodate large industrial and housing installations. In the Duwamish Valley, the fill ranges from about 3 feet to more than 12 feet thick, and from gravelly sandy loam to gravelly loam in texture. The erosion hazard is slight to moderate (OpTech 1995).

Two soil borings were drilled at the Seattle ANGS and five Dutch cone penetrometer samples were analyzed by Hart Crowser and Associates, Inc., during soil studies conducted at the Station in 1974 and 1982. Sandy silt to silty sand was the most common sediment within the uppermost 10 feet of unconsolidated sediments. Sand, with occasional thin silty layers, was the predominant lithology encountered from a depth of 10 to 50 feet bgs (OpTech 1995).

3.5 Surface Water Hydrology

The Seattle ANGS is located approximately 1/2 mile from the main channel of the Duwamish Waterway, a major surface water drainage for western Washington. Between 1917 and 1919, the meanders of the Duwamish River within Seattle City limits were filled in and the Duwamish Waterway was formed. A portion of a meander near North Boeing Field was not filled in, and this became the present-day Slip No. 4 (see Figure 1-1).

The Federal Emergency Management Agency reported that the Duwamish drainage basin comprises 450 square miles. The drainage basin includes the Duwamish and Green Rivers. Approximately 3.5 miles northwest of the Station, the Duwamish Waterway discharges into Elliot Bay on the Puget Sound.

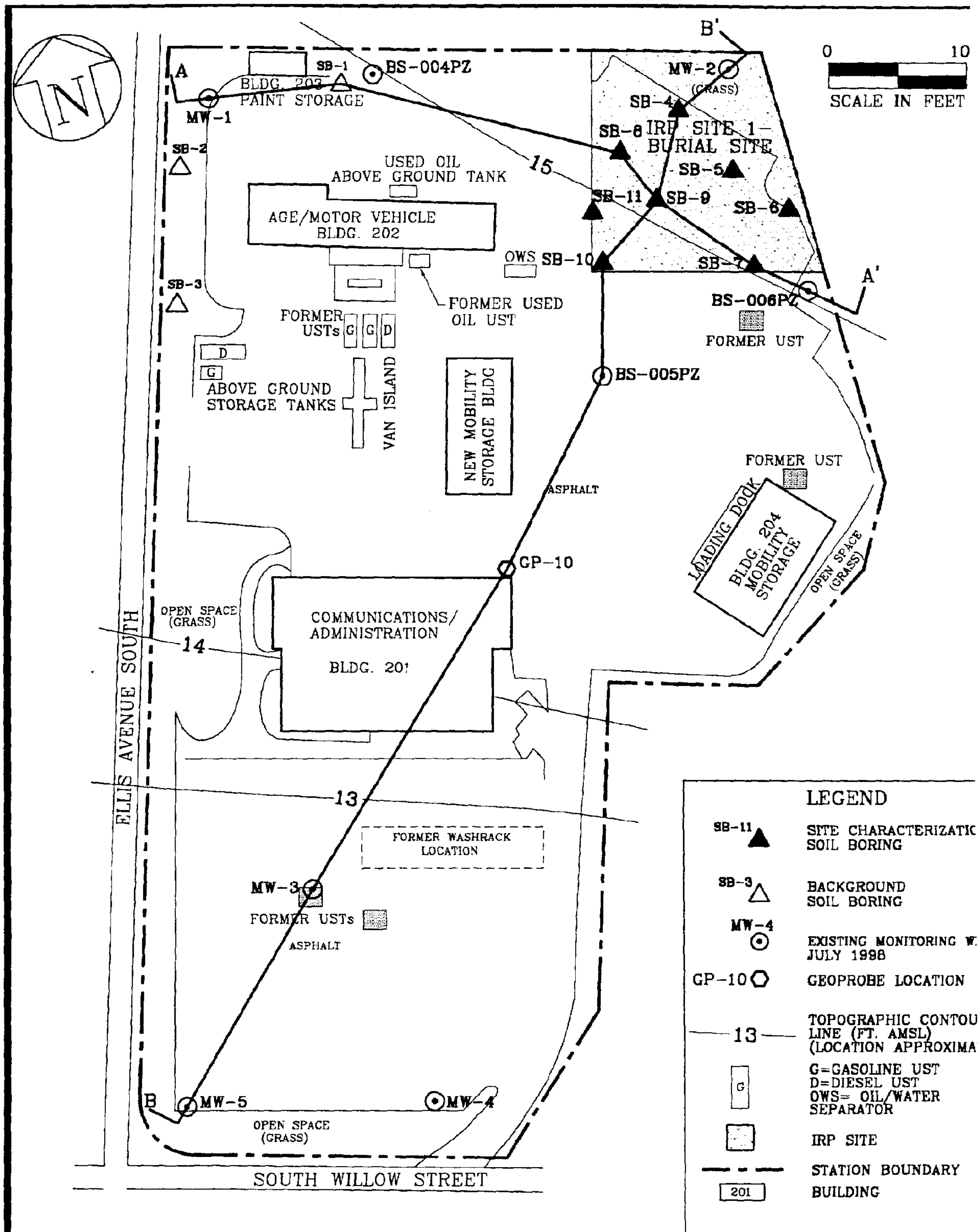

FIGURE 3-3

GEOLOGIC CROSS-SECTION
LOCATION MAP

143rd CCSQ, Seattle ANGS
Seattle, Washington

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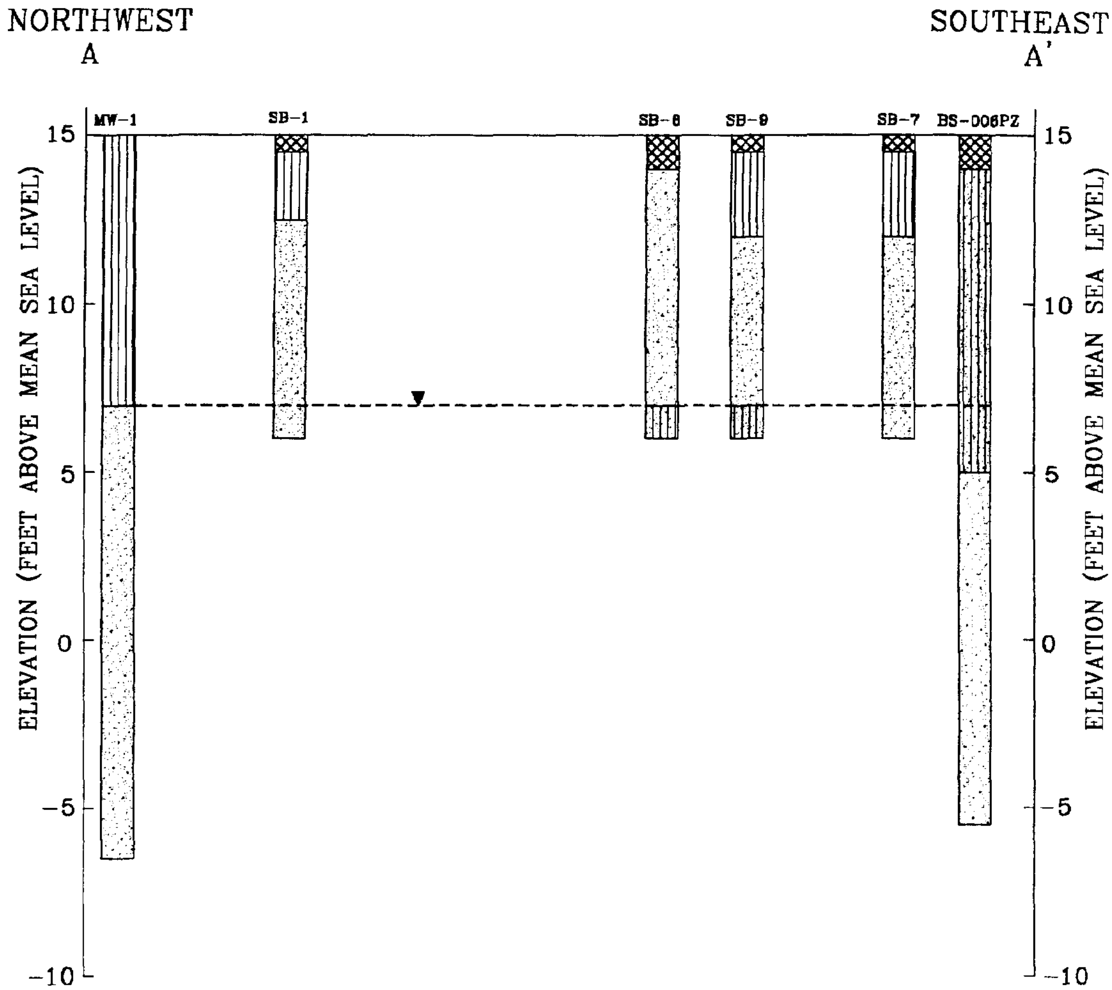

LEGEND

SAND AND GRAVEL SUBBASE

SILTY SAND / SANDY SILT

WATER TABLE

SILT

SAND

0 100 HORIZONTAL SCALE IN FEET

FIGURE 3-4

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GEOLOGIC CROSS-SECTION A-A'

143rd CCSQ, Seattle ANGS
Seattle, Washington

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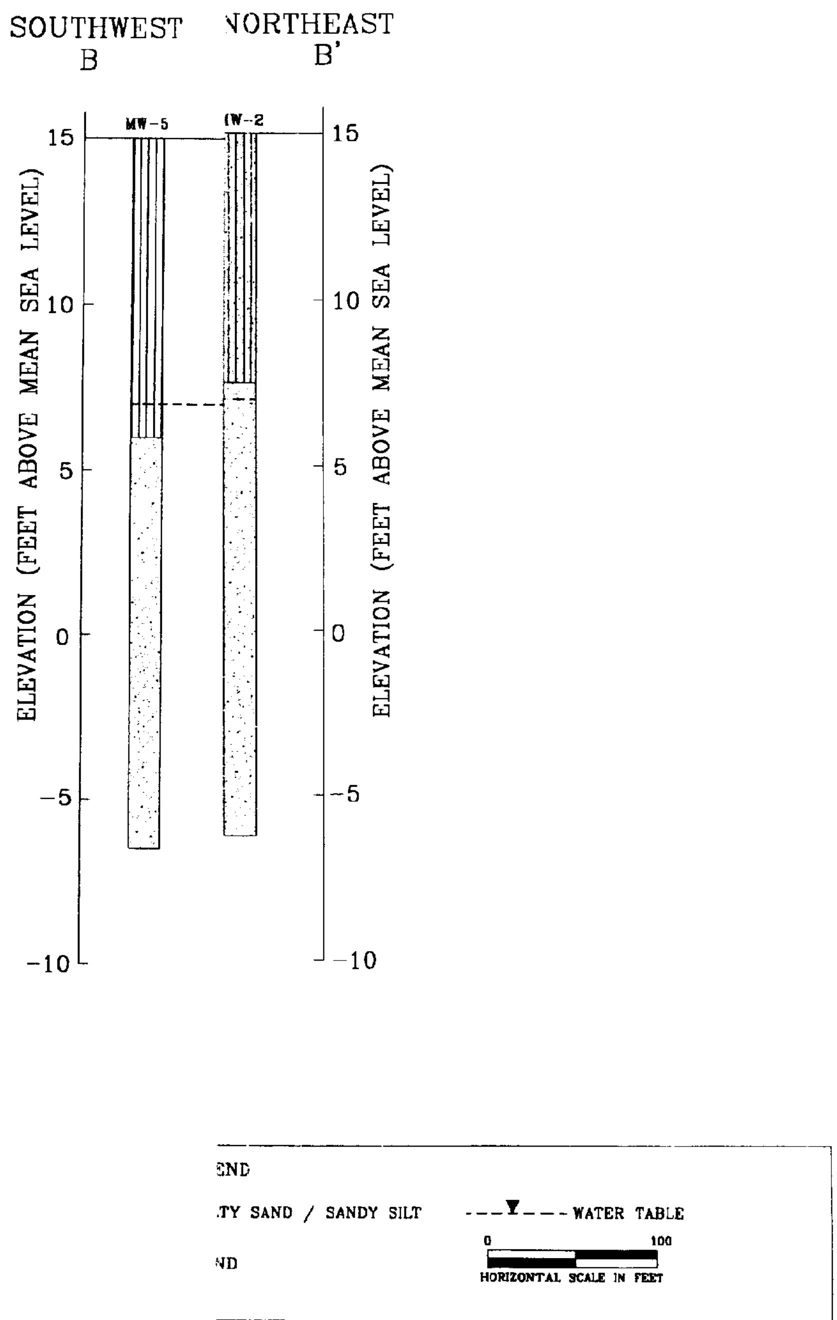

FIGURE 3-5

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ERM

The Duwamish Waterway is the only fresh water body downgradient of the Station. According to the Seattle Water Department, the Duwamish Waterway is not used for drinking water (OpTech 1995). Surface water runoff at the Seattle ANGS flows into a series of catch basins that are tied into the municipal storm sewer. Figure 3-6 illustrates the storm drain system at the Station.

3.6 Hydrogeology

This section describes the regional and local hydrogeology in the vicinity of the Seattle ANGS and summarizes the hydrogeologic conditions encountered at the Station during the RI.

3.6.1 Regional Hydrogeology

Groundwater in the Duwamish Valley occurs in two lithostratigraphic units. Shallow groundwater is present within a river alluvium unit. This unit underlies the Seattle ANGS and is described in the following section. Deeper groundwater reportedly exists beneath the river alluvium unit in unconsolidated glacial deposits (Luzier 1969). Characteristics of this deeper aquifer are unknown; groundwater probably flows toward the Duwamish River and thus to Elliot Bay within the deeper aquifer (OpTech 1995).

The Seattle Water Department has no municipal wells within 4 miles of the Station, and records obtained from the WDOE indicate that there are no private drinking water wells within a 1-mile radius of the Station. The surrounding population obtains drinking water from a municipal water source (OpTech 1995).

The EDR environmental database report prepared as part of the Phase I RI/FS Work Plan presents data regarding water supply wells in the USEPA's database and wells included in the United States Geological Survey's database. The wells identified in the EDR report are greater than 1 mile from the Seattle ANGS (ERM 1996).

The PA/SI Report identified wells within a 4-mile radius of the Seattle ANGS. The wells were identified based on a review of State records. Construction details, use, and ownership information for the wells identified during the PA/SI are summarized in OpTech (1995).

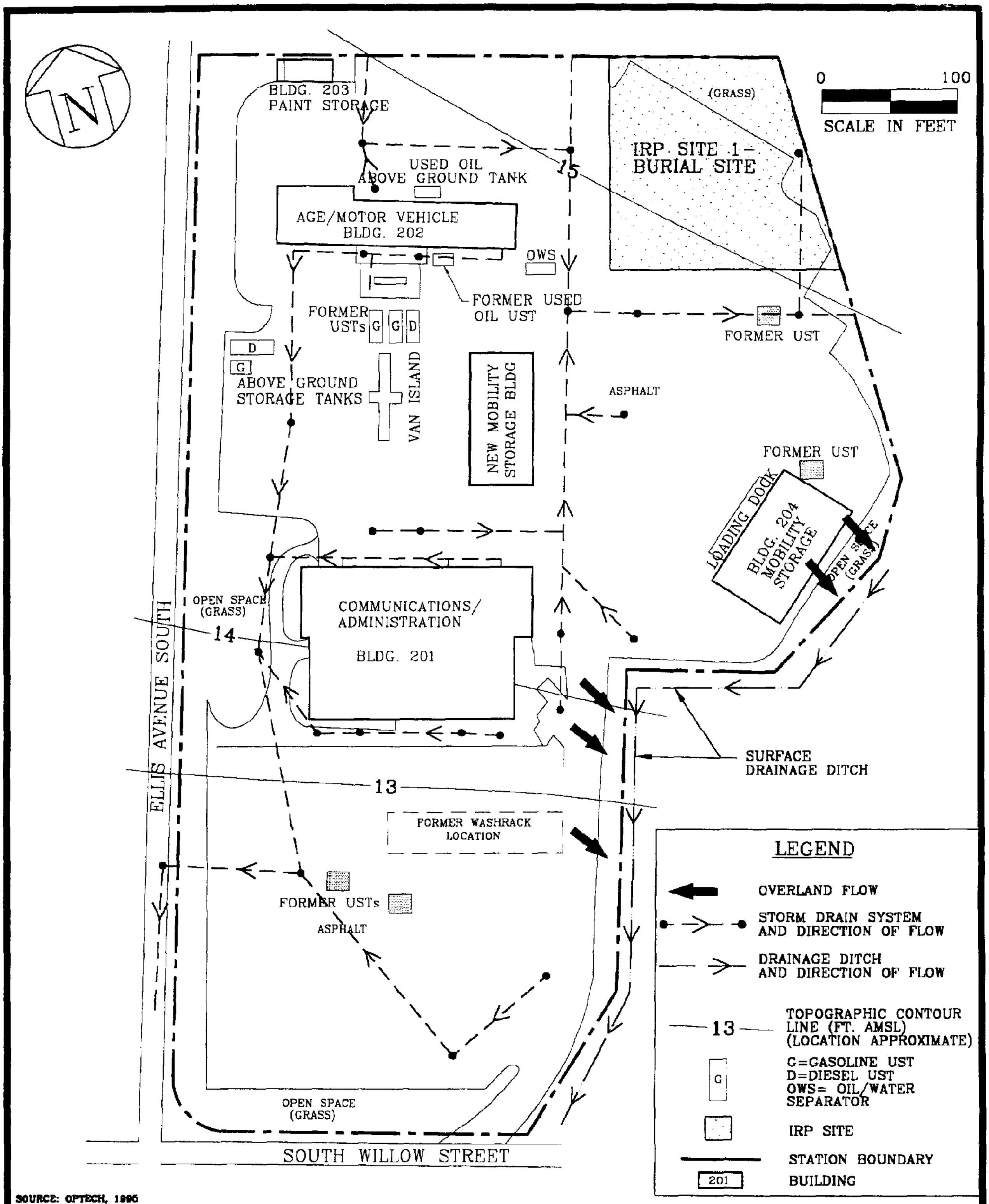

FIGURE 3-6

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SURFACE WATER DRAINAGE MAP

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

3.6.2 Local Hydrogeology

Unconfined groundwater generally occurs at depths of 4 to 11 feet bgs in the vicinity of the Seattle ANGS, within the upper part of the recent river alluvium. Previous investigations in the area have found that groundwater elevations are influenced by seasonal precipitation, and, if close enough to the Duwamish Waterway, by tidal fluctuations. Groundwater flow in the vicinity of the Station is generally toward the west, southwest, and south, toward the Duwamish Waterway, at a gradient of approximately 0.002 feet per foot (OpTech 1995).

3.6.3 Site Hydrogeologic Conditions

Hydrogeologic data collected during the Phase I RI indicate that unconfined groundwater exists at depths of 6 to 10 feet bgs at the Seattle ANGS. The inferred groundwater flow direction is toward the south. Representative potentiometric surface maps generated from the Phase I RI groundwater elevation data are shown on Figures 3-7 and 3-8. As shown on Figures 3-7 and 3-8, groundwater at the Station responds quickly to seasonal precipitation during the wet season; groundwater elevations increased approximately 2 feet between October 1996 and January 1997.

Slug tests were performed on monitoring well MW-3 during the Phase I RI. Hydraulic conductivity estimates ranging from 1.25×10^{-4} to 6.09×10^{-4} feet per second were calculated for monitoring well MW-3. These results are consistent with the predominant sand lithology at the site.

3.7 Critical Habitats and Endangered/Threatened Species

No critical habitats or endangered or threatened species have been identified within 4 miles of the Seattle ANGS (OpTech 1995).

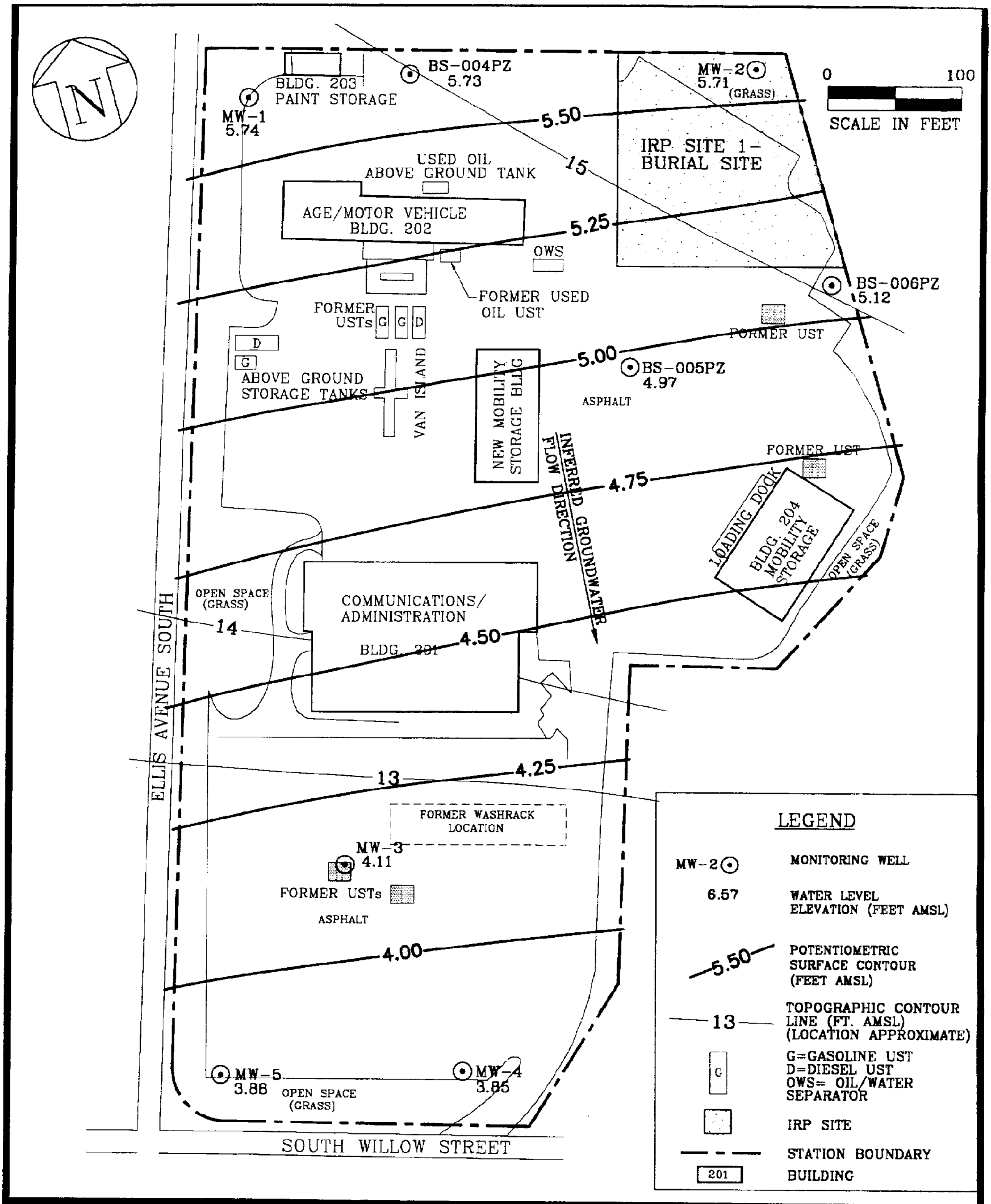

FIGURE 3-7

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POTENTIOMETRIC SURFACE
22 OCTOBER 1996

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

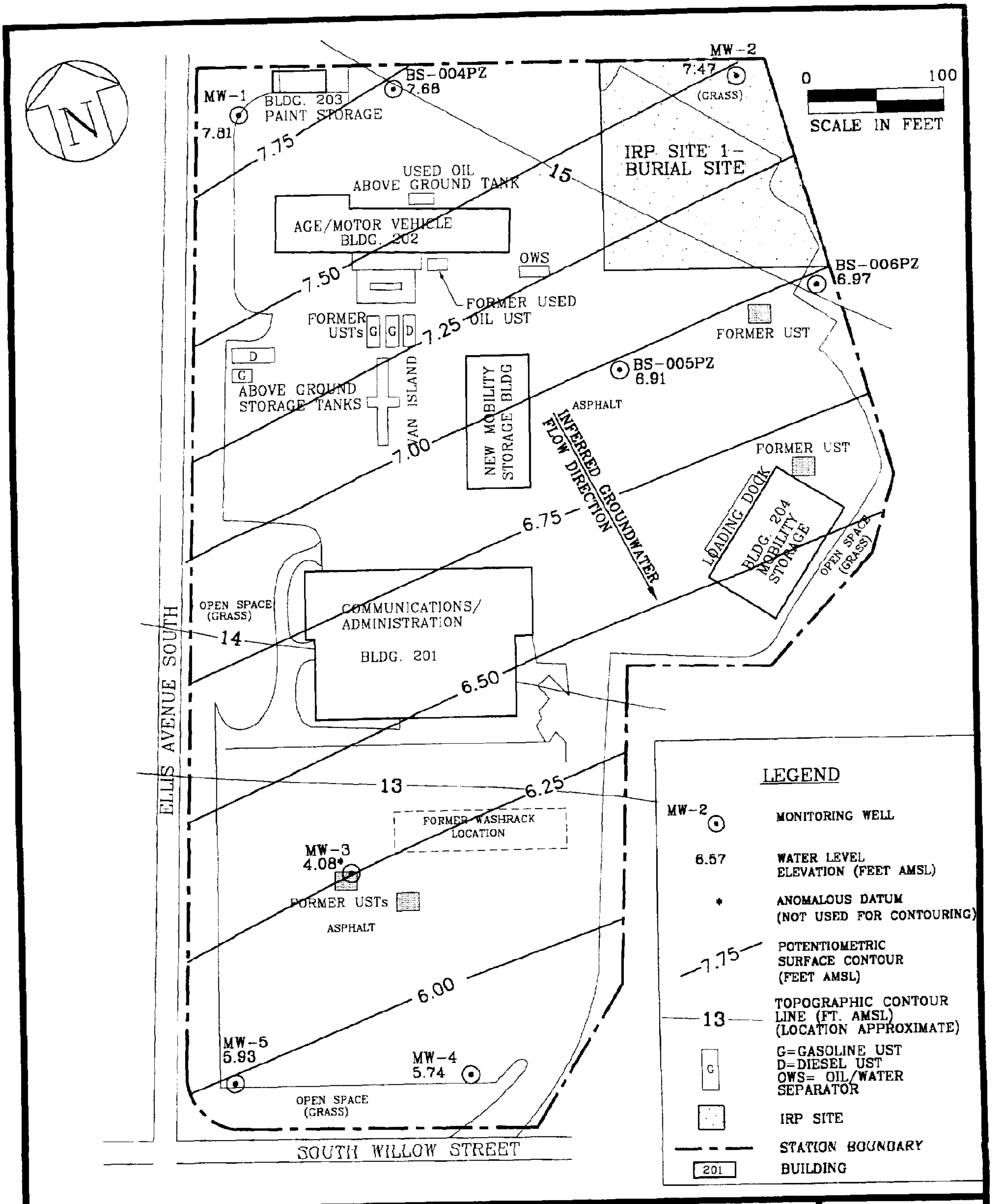

FIGURE 3-8

POTENTIOMETRIC SURFACE
14-15 JANUARY 1997

143rd CCSQ, Scattle ANGS
Seattle, Washington

ERM

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SECTION 4.0

FIELD PROGRAM METHODS

4.1 Summary

This section summarizes the elements of the Phase II RI field program. Deviations from the Phase II RI/FS Work Plan (ERM 1998b), data validation, and disposition of investigation-derived wastes are also described. The results of the Phase II RI field investigation are presented in Section 5.0.

The purpose of the Phase II RI was to further define the nature and extent of COPCs in soil and groundwater at the Seattle ANGS. Specifically, the objectives of the Phase II RI field investigation were to:

- Identify and characterize potential sources and extent of VOCs in shallow soil and groundwater;
- Determine trends in the concentrations of VOCs in groundwater and evaluate compliance with ARARs; and
- Determine the lateral extent of petroleum hydrocarbon contamination in soil surrounding PA/SI soil boring BS-003BH.

Field investigations were conducted in the southern and northwest portions of the Station where VOCs were previously detected in groundwater during Phase I. Technical memoranda for field activities are included in Appendix A. The Phase II field investigation consisted of the following activities:

- Collection of subsurface soil vapor, soil, and groundwater samples using direct-push technology;
- Installation and quarterly sampling of groundwater monitoring wells; and

- A location and elevation survey of the Phase II RI direct-push soil and groundwater sampling locations and groundwater monitoring wells.

4.2 Deviations from the Work Plan

Five deviations from the Phase II RI/FS Work Plan occurred during field activities:

- The direct-push boreholes were abandoned by simultaneously pouring bentonite chips and tap water into the open holes instead of by grouting with a tremie pipe as specified in the Work Plan.

- The field quality assurance/quality control (QA/QC) sample naming convention (sample identifiers) differed from the convention described in the Work Plan. This change was implemented to simplify subsequent data review.

- During the first quarterly groundwater sampling event, all of the monitoring wells at the Station (13 wells total) were sampled after the five new Phase II wells were installed. The Work Plan indicated that the eight pre-existing wells would be sampled prior to the soil vapor survey, and that the five new wells would be sampled following completion and development of these wells.

- One soil sample was collected from each new monitoring well boring for VOC analysis (five samples total); the collection of soil samples from monitoring well borings was not included in the Work Plan.

- Beginning with the second quarterly groundwater sampling event, isopropanol was used instead of methanol for the final equipment decontamination spray rinse. This change was implemented to avoid the hazardous waste storage and handling issues associated with spent methanol.

These deviations were approved by the ANG Project Manager. No other deviations from the Phase II RI/FS Work Plan occurred during field activities.

4.3 Field-Screening Activities

Soil samples collected during the Phase II RI were field-screened for organic vapors using a photoionization detector (PID). The following procedure was used to field-screen soil samples. First, a portion of each soil sample was placed in a re-sealable plastic bag and the bag was immediately sealed. The sample was then gently agitated for approximately 30 seconds and left to equilibrate at ambient temperature (out of direct sunlight) for at least 15 minutes. Following the equilibration period, the total organic vapor concentration of the soil sample was measured by carefully pushing the PID probe through the wall of the plastic bag into the headspace above the sample. The maximum PID reading observed for each sample was recorded on the borehole log (Appendix B).

4.4 Confirmation Activities

This section describes the confirmation activities performed during the Phase II RI. A summary of the sampling and analytical testing conducted during the Phase II RI is provided on Table 4-1.

4.4.1 Soil Vapor Sampling

Soil vapor samples were collected from 40 locations to screen for potential sources of VOCs in soil. The soil vapor survey focused on the northwest and southern portions of the Station, where VOCs were previously detected in groundwater at concentrations above ARARs. The soil vapor sampling locations are shown on Figure 4-1. The soil vapor samples were collected from approximately 5 feet bgs using a StrataProbe direct-push rig and were analyzed for VOCs in a mobile field laboratory.

4.4.2 Direct-Push Soil and Groundwater Sampling

Direct-push subsurface soil and groundwater samples were collected from 20 locations to characterize the extent and potential sources of VOCs in shallow soil and groundwater. The direct-push soil and groundwater sampling focused on the northwest and southern portions of the Station

TABLE 4-1

Phase II RI Sampling and Analytical Testing Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Matrix	Sampling Method	Field Parameters	Laboratory Parameters	Analytical Method	Primary Sample Analyses	QA/QC Samples					Total Laboratory Analyses
						Trip Blank	Rinsate Blank	Field Blank	Field DUP	MS/MSD	
Soil Vapor	StrataProbe - 40 locations	None	VOCs	USEPA 8021B	40	2	4	2	4	--	52
Soil	StrataProbe - 20 locations	Organic vapors	VOCs	USEPA 8260	20	1	2	1	2	1	27
			TPH	WTPH-HCID	3	--	1	1	1	--	6
	MW borings - 5 locations	Organic vapors	VOCs	USEPA 8260	5	1	1	--	--	--	7
Groundwater	StrataProbe - 20 locations	None	VOCs	USEPA 8021B	20	1	1	1	2	1	26
	8 existing MWs, 5 new MWs, quarterly for 1 year	S.C., Turbidity, pH, Temperature, D.O., Redox potential	VOCs	USEPA 8260	52	8	5	8	5	3	81

VOCs = Volatile organic compounds
TPH = Total petroleum hydrocarbons
WTPH-HCID = Washington TPH - hydrocarbon identification method
QA/QC = Quality assurance/quality control
DUP = Duplicate sample

S.C. = Specific conductance
D.O. = Dissolved oxygen content
USEPA = United States Environmental Protection Agency
MS/MSD = Matrix spike/matrix spike duplicate
MW = Monitoring well

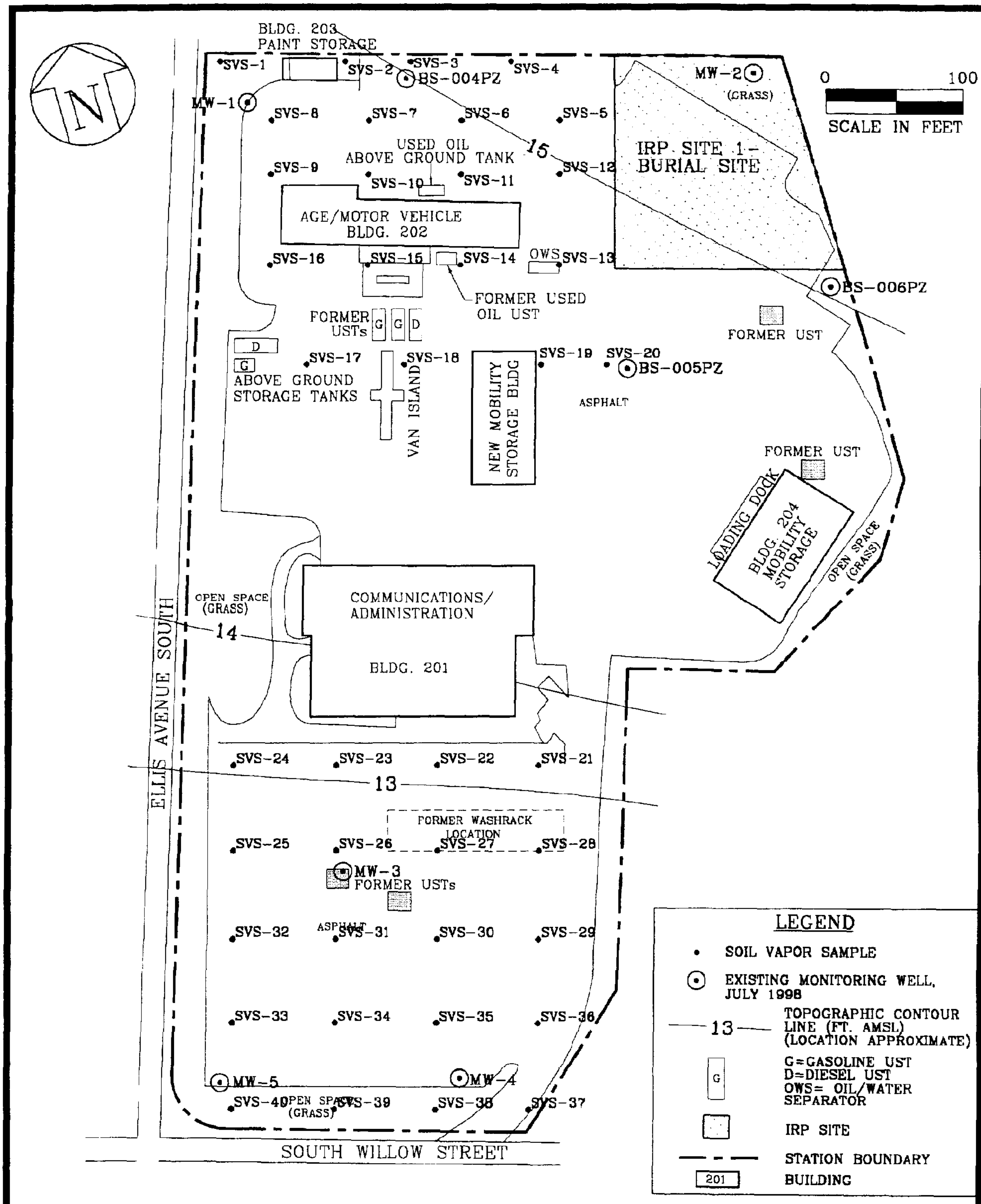

FIGURE 4-1	PHASE II RI SOIL VAPOR SAMPLING LOCATIONS 143rd CCSQ, Seattle ANGS Seattle, Washington	ERM
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SEA407847

(Figure 4-2). A StrataProbe rig was used to collect the samples. Soil samples were collected from just above the water table and were analyzed for VOCs at an off-site State-certified laboratory. Groundwater samples were collected from approximately 2.5 feet below the water table and were analyzed for VOCs in a mobile field laboratory.

4.4.3 Groundwater Monitoring Well Installation

Five groundwater monitoring wells (MW-6 through MW-10) were installed during the Phase II RI. The monitoring wells were installed to further define the lateral extent of VOCs in shallow groundwater and to monitor compliance of VOC concentrations with ARARs. The locations of monitoring wells at the Seattle ANGS are shown on Figure 4-2. Table 4-2 provides construction information for the monitoring wells. Borehole logs and well construction diagrams for the monitoring wells installed during Phase II are included in Appendix B.

4.4.4 Groundwater Monitoring

The new and existing groundwater monitoring wells at the Station (13 wells total; Figure 4-2) were sampled on a quarterly basis for 1 year. The purpose of the groundwater monitoring was to assess compliance with ARARs and trends in concentrations of VOCs. The quarterly groundwater samples were analyzed for VOCs at an off-site State-certified laboratory.

Water levels were measured in the monitoring wells at the beginning of each sampling event. The groundwater levels were contoured and used to estimate groundwater flow directions at the Station.

4.4.5 Specific Media Sampling

This section summarizes the sampling and analytical methods used during the Phase II RI. The Phase II RI/FS Work Plan (ERM 1998b) provides further details regarding monitoring well installation and the specific sample collection procedures that were used.

4.4.5.1 Soil Vapor

Soil vapor samples were collected from approximately 5 feet bgs using a hydraulically-driven sampling probe consisting of threaded sections of

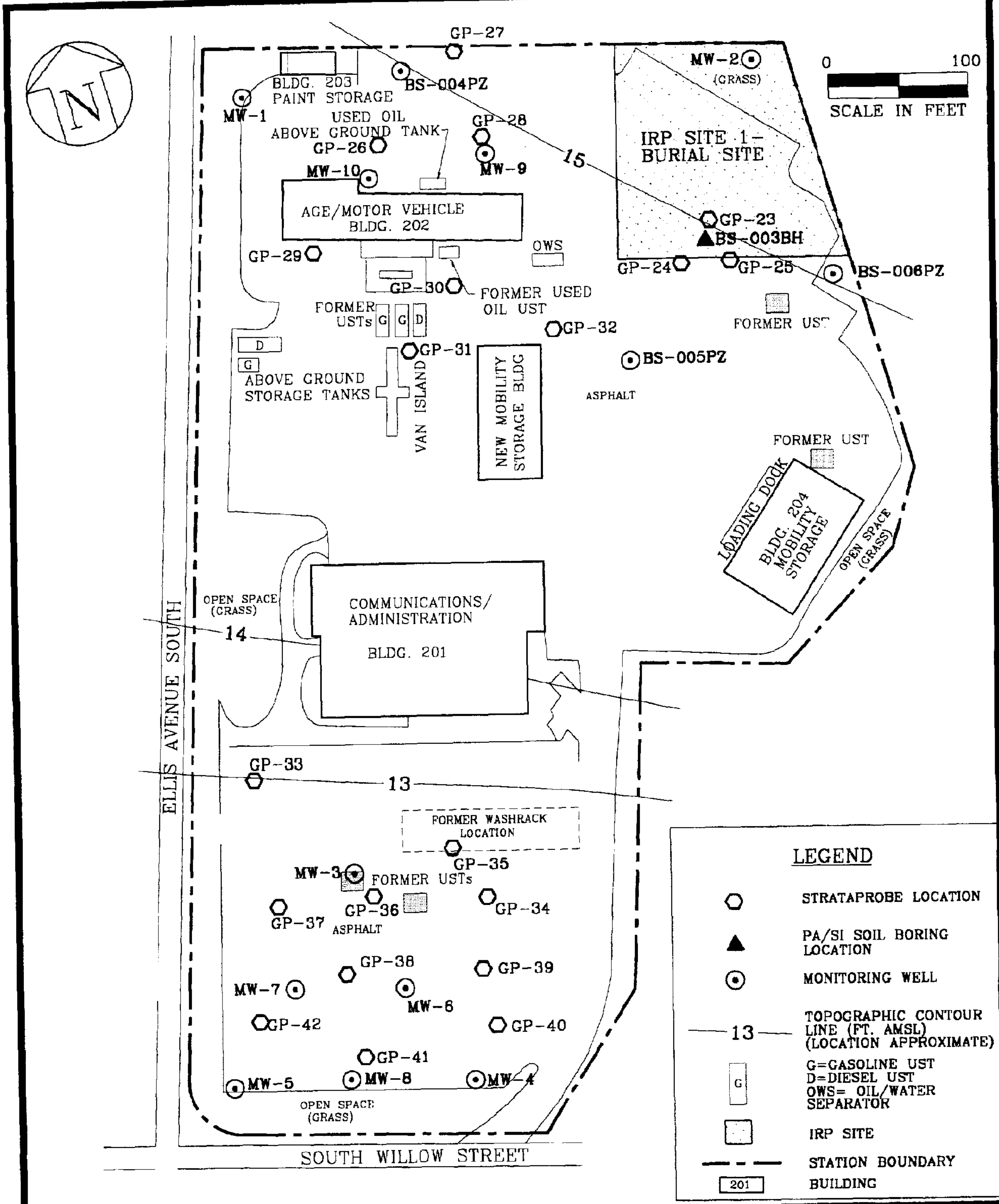

FIGURE 4-2

PHASE II RI SOIL AND GROUNDWATER SAMPLING LOCATIONS

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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TABLE 4-2

Monitoring Well Installation Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	IRP Investigation	Date Completed	Measuring Point Elevation (ft-amsl)	Total Depth (ft-bgs)	Casing Diameter/ Material	Wellhead Completion	Screen Slot Size (inches)	Annular Seal	Screened Interval (ft-bgs)	Top of Sand Filter Pack (ft-bgs)
BS-004PZ (Background Well)	PA/SI	7/14/94	14.66	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7.0
MW-1 (Background Well)	Phase I RI	10/16/96	14.92	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
BS-005PZ	PA/SI	7/14/94	14.39	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7.0
BS-006PZ	PA/SI	7/14/94	14.59	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7.0
MW-2	Phase I RI	10/16/96	14.60	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-3	Phase I RI	10/17/96	11.88	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-4	Phase I RI	10/17/96	12.05	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-5	Phase I RI	10/17/96	13.94	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-6	Phase II RI	8/27/98	11.62	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-7	Phase II RI	8/27/98	12.17	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-8	Phase II RI	8/27/98	11.90	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-9	Phase II RI	8/27/98	14.30	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-10	Phase II RI	8/27/98	14.97	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0

(ft-amsl) = Feet above mean sea level
(ft-bgs) = Feet below ground surface
RI = Remedial Investigation
PA/SI = Preliminary Assessment/Site Inspection
PVC = Polyvinyl chloride
BC = Bentonite chips

1-inch diameter stainless-steel pipe. The sampling probe was fitted with a detachable drive point. After the sampling probe was advanced to the desired depth, it was retracted slightly to allow soil vapors to enter the probe. A vacuum pump was then used to purge ambient air from the sampling probe and extract soil vapors. The soil vapor samples were collected from the sampling probe using a gas-tight syringe and were transferred to evacuated glass vials with Teflon-lined septa for subsequent analysis in an on-site mobile field laboratory operated by Transglobal Environmental Geosciences Northwest, Inc., (TEG Northwest). The soil vapor samples were analyzed in accordance with the analytical testing summary provided on Table 4-1.

4.4.5.2 Soil

Subsurface soil samples were collected from 20 StrataProbe direct-push sampling locations and from 5 monitoring well borings installed using a hollow-stem auger drill rig.

StrataProbe soil samples were collected from just above the water table by hydraulically pushing a split-spoon drive sampler lined with stainless-steel sleeves to the desired sampling depth. Soil at shallower depths was prevented from entering the drive sampler by a center steel rod. At the specified sampling depth the center rod was removed and the drive sampler was pushed into undisturbed soil at the bottom of the boring. A portion of each soil sample collected was field-screened for organic vapors as described in Section 4.3. The remaining undisturbed portion of each soil sample was stored on ice in a cooler and submitted under chain-of-custody to MultiChem Analytical Services in Renton, Washington, for analytical testing. The StrataProbe soil samples were analyzed in accordance with Table 4-1.

The soil samples collected from the monitoring well borings also were collected from just above the water table using a split-spoon drive sampler. However, in this case, the sampler was driven into undisturbed soil at the bottom of each borehole using a drop hammer on the hollow-stem auger drill rig. The well-boring soil samples were otherwise handled and analyzed the same as the StrataProbe soil samples (per Table 4-1).

4.4.5.3 Groundwater

Groundwater samples were collected from 20 StrataProbe direct-push sampling locations and from 13 groundwater monitoring wells.

The StrataProbe groundwater sampling device consists of a drive point, a slotted section of stainless-steel screen for sample intake, and a retractable sleeve. The StrataProbe rig pushed the sampling device through the soil to the desired sampling depth (approximately 2.5 feet below the water table). The sleeve was then retracted, exposing the screen section and allowing groundwater to flow into the sample probe. A peristaltic pump was used to transfer groundwater from the sample probe to glass volatile organics analysis (VOA) vials for subsequent analysis in an on-site mobile field laboratory operated by TEG Northwest. The StrataProbe groundwater samples were analyzed in accordance with Table 4-1.

Groundwater monitoring wells were sampled as follows. First, static water levels in the wells were measured to within ±0.01 foot using an electronic water level indicator. The monitoring wells were then purged and sampled using low-flow methods. Using a stainless-steel submersible pump, each well was purged at a rate of less than 1 liter per minute. The temperature, pH, specific conductance, turbidity, dissolved oxygen content, and redox potential of the purge water were monitored during well purging using an in-line flow cell. Purging continued until the purge-water parameters stabilized. Groundwater samples were then collected in glass VOA vials. The monitoring-well groundwater samples were stored on ice in a cooler and submitted under chain-of-custody to MultiChem Analytical Services for analytical testing in accordance with Table 4-1.

4.5 Field Quality Assurance/Quality Control

This section describes the field QA/QC procedures employed during Phase II RI field activities at the Seattle ANGS.

4.5.1 Field Documentation

Field activities were documented in daily log books and field forms. Subsurface lithologies and PID readings observed during the StrataProbe sampling and monitoring well installation were recorded in field notes and on borehole logs. Groundwater monitoring information was recorded on groundwater sampling forms. The borehole logs and groundwater sampling forms were kept in a bound notebook. Additionally, field activities were documented with photographs.

4.5.2 Equipment Decontamination

Before each use, soil sampling equipment that directly contacted soil samples was washed with a solution of tap water and Liqui-Nox (a laboratory-grade detergent), then rinsed with American Society for Testing and Materials (ASTM) Type II regeant-grade water and high-performance-liquid-chromatography-grade (HPLC-grade) methanol, then rinsed again with ASTM Type II water. Auger flights used for drilling were decontaminated before each use by steam cleaning. The electronic water level indicator and the housing of the submersible pump used for purging and sampling the monitoring wells were decontaminated before each use by washing with a solution of tap water and Liqui-Nox or Alconox, and rinsing with ASTM Type II water and HPLC-grade methanol or isopropanol. The submersible pump internals and non-disposable tubing were decontaminated by pumping a Liqui-Nox or Alconox solution, followed by ASTM Type II water, through the pump and tubing.

4.5.3 Field QA/QC Samples

The number and type of field QA/QC samples collected, and the analyses performed on the samples, are summarized on Table 4-1.

Field duplicate samples, field blanks, trip blanks, equipment rinsate blanks, and matrix spike/matrix spike duplicate (MS/MSD) samples were submitted to the analytical laboratory to assess the quality of the data resulting from the field sampling program. Duplicate samples were collected at a minimum frequency of one per ten primary samples per matrix. Field blanks were collected at a minimum frequency of one tap water blank and one ASTM Type II water blank per sampling event. Trip blanks were collected at a frequency of one per cooler containing samples for VOC analysis. Equipment rinsate blanks were collected at a minimum frequency of one per ten primary samples per matrix. MS/MSD samples were collected at a minimum frequency of one MS/MSD pair per 20 field samples.

4.5.4 Soil Sample Preservation

Soil samples submitted for laboratory analysis were contained in stainless-steel sleeves. Immediately after collecting each sample, the ends of the filled sleeve were covered first with a sheet of Teflon (a moisture barrier), then aluminum foil, and finally with a fitted plastic cap. Samples were then placed in individual resealable plastic bags and stored in a cooler with enough ice to maintain samples at a temperature of less than 4 degrees Celsius (°C). Holding times for soil samples analyzed during the Phase II RI are summarized on Table 4-3. The holding time is defined as the maximum length of time that samples should be held before the completion of analytical protocols.

4.5.5 Groundwater Sample Preservation

Groundwater samples for VOC analysis were collected in 40-milliliter glass VOA vials with Teflon-lined septa. The VOA vials contained enough hydrochloric acid preservative to maintain samples at a pH of less than 2, and the vials were filled completely to eliminate headspace. The groundwater samples were stored in coolers with enough ice to maintain samples at a temperature of less than 4 °C. Holding times for water samples analyzed during the Phase II RI are summarized on Table 4-3.

4.6 Analytical Data Review and Validation

The quality assurance (QA) effort for this project included a comprehensive review of the laboratory analytical data for conformance with the project data quality objectives specified in the Phase II RI/FS Work Plan (ERM 1998b). In addition, analytical data packages consistent with USEPA Contract Laboratory Program (CLP) reporting requirements were requested for approximately 10 percent of the Phase II soil samples and 100 percent of the Phase II groundwater samples. The analytical data reported in the CLP-like data packages were validated in accordance with *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (February 1994).

The results of the QA analytical data review and validation are summarized in Section 5.0. Appendix F contains the QC data review/validation reports for the Phase II analytical data.

TABLE 4-3

Summary of Sample Holding Times for Water and Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Parameter	Holding Time
	<u>Water Samples</u>
VOCs	Analyze within 14 days of collection.
	<u>Soil Samples</u>
VOCs	Analyze within 14 days of collection.
TPH	Extract within 7 days of collection and analyze within 40 days of extraction.

VOCs = Volatile organic compounds
TPH = Total petroleum hydrocarbons

4.7 Borehole Abandonment

The StrataProbe borings were abandoned using hydrated bentonite chips. The bentonite chips and water were poured simultaneously into the open borehole and filled to the surface. Cold-patch asphalt was used to seal the surface and match the surrounding pavement.

4.8 Land Surveying

The locations and surface elevations of the Phase II RI StrataProbe soil and groundwater sampling locations and monitoring wells were surveyed by Landmark Incorporated of Bellevue, Washington. Vertical survey data were tied to the United States Coastal and Geodetic Survey monument "Boeing G," a second-order benchmark adjusted in 1973 with an elevation of 10.58 feet National Geodetic Vertical Datum of 1929. Planned vertical and horizontal accuracies for the survey were ±0.01 feet and ±0.1 feet, respectively. Coordinates and elevation data for the RI sampling locations are included in Appendix C.

4.9 Investigation-Derived Waste Management

Wastes generated during the Phase II RI field activities consisted of soil cuttings generated during StrataProbe sampling and monitoring well installation, equipment decontamination water, monitoring well purge water, and solid wastes (e.g., waste paper and plastic). Soil cuttings, decontamination water, and purge water were contained in labeled 55-gallon steel drums. The drums were stored in a paved staging area near the IRP site. Uncontaminated solid wastes generated during the field work were disposed of with regular Station trash. Additional details regarding management of investigation-derived wastes are provided in Appendix D.

SECTION 5.0

INVESTIGATION FINDINGS

This section presents the findings of the Phase II RI conducted at the Seattle ANGS. The findings are discussed in the context of previous investigation results and compliance with chemical-specific ARARs.

5.1 Installation-Wide Geologic and Hydrologic Investigation Results

Subsurface data collected during the PA/SI and RI indicate that the near-surface geology at the Seattle ANGS is predominantly composed of two units. The first unit is a silty sand fill material present to a depth of approximately 8 feet bgs. The fill material is consistent with the descriptions of the material that was used to raise the Duwamish Valley for development in the 1910s. The second unit consists primarily of poorly graded, fine-grained sand present from approximately 8 feet bgs to the maximum depth of the borings drilled during the PA/SI and RI. Geologic cross-sections through the site are shown on Figures 3-3, 3-4, and 3-5.

Unconfined groundwater occurs at approximately 6 to 10 feet bgs at the Station. Static water levels measured in the monitoring wells during the Phase I and II RI are summarized on Table 5-1. Periodic water level measurements collected on 2 September 1998 from monitoring wells MW-3, MW-4, and MW-5 indicate that groundwater at the Seattle ANGS is not tidally influenced. Water levels in these wells did not change significantly over an 8.5-hour period, even though the tide increased almost 10 feet during the same period (Figure 5-1).

Representative potentiometric maps for the monitoring period April 1997 to May 1999 are shown on Figures 5-2 through 5-6. The inferred groundwater flow direction during the period was predominantly toward the south, and the average hydraulic gradient was nearly constant at approximately 0.0025 feet per foot. The reason for the apparent southeasterly groundwater flow direction and increased gradient in the southern portion of the Station on 24 November 1998 (Figure 5-4) is unclear.

TABLE 5-1

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Monitoring Well	Measuring Point Elevation (ft amsl)	Date	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
BS-004PZ (Background Well)	14.66	9/17/96	8.88	5.78
		10/22/96	8.93	5.73
		12/17/96	8.08	6.58
		1/14/97	6.98	7.68
		4/11/97	7.23	7.43
		7/10/97	8.08	6.58
		9/1/98	9.79	4.87
		11/24/98	9.39	5.27
		2/24/99	6.84	7.82
		5/18/99	7.81	6.85
BS-005PZ	14.39	9/17/96	9.16	5.23
		10/22/96	9.42	4.97
		12/17/96	8.51	5.88
		1/15/97	7.48	6.91
		4/10/97	7.65	6.74
		7/11/97	8.47	5.92
		9/1/98	10.12	4.27
		11/24/98	9.41	4.98
		2/24/99	7.32	7.07
		5/18/99	8.15	6.24
BS-006PZ	14.59	9/17/96	9.12	5.47
		10/22/96	9.47	5.12
		12/17/96	8.54	6.05
		1/14/97	7.62	6.97
		4/11/97	7.77	6.82
		7/11/97	8.49	6.10
		9/1/98	10.29	4.30
		11/24/98	9.37	5.22
		2/24/99	7.42	7.17
		5/18/99	8.20	6.39
MW-1 (Background Well)	14.92	10/22/96	9.18	5.74
		12/17/96	8.20	6.72
		1/14/97	7.11	7.81
		4/10/97	7.58	7.34
		7/11/97	8.51	6.41
		9/1/98	10.22	4.70
		11/24/98	9.45	5.47
		2/24/99	7.12	7.80
		5/18/99	8.25	6.67

TABLE 5-1

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Monitoring Well	Measuring Point Elevation (ft amsl)	Date	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
MW-2	14.60	10/22/96	8.89	5.71
		12/17/96	8.03	6.57
		1/15/97	7.13	7.47
		4/10/97	7.25	7.35
		7/11/97	7.98	6.62
		9/1/98	9.59	5.01
		11/24/98	9.75	4.85
		2/24/99	6.70	7.90
		5/18/99	7.71	6.89
MW-3	11.88	10/22/96	7.77	4.11
		12/17/96	6.78	5.10
		1/15/97	7.80	4.08
		4/11/97	6.06	5.82
		7/11/97	6.94	4.94
		9/1/98	8.09	3.79
		11/24/98	7.20	4.68
		2/24/99	5.56	6.32
		5/18/99	6.65	5.23
MW-4	12.05	10/22/96	8.20	3.85
		12/17/96	7.21	4.84
		1/14/97	6.31	5.74
		4/11/97	6.65	5.40
		7/11/97	7.43	4.62
		9/1/98	8.21	3.84
		11/24/98	8.14	3.91
		2/24/99	6.08	5.97
		5/18/99	7.16	4.89
MW-5	13.94	10/22/96	10.06	3.88
		12/17/96	9.06	4.88
		1/14/97	8.01	5.93
		4/11/97	8.36	5.58
		7/10/97	9.23	4.71
		9/1/98	10.15	3.79
		11/24/98	10.11	3.83
		2/24/99	7.84	6.10
		5/18/99	8.98	4.96
MW-6	11.62	9/1/98	8.38	3.24
		11/24/98	7.64	3.98
		2/24/99	5.50	6.12
		5/18/99	6.55	5.07

TABLE 5-1

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Monitoring Well	Measuring Point Elevation (ft amsl)	Date	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
MW-7	12.17	9/1/98	6.75	5.42
		11/24/98	7.30	4.87
		2/24/99	5.94	6.23
		5/18/99	7.05	5.12
MW-8	11.90	9/1/98	8.89	3.01
		11/24/98	8.02	3.88
		2/24/99	5.82	6.08
		5/18/99	6.95	4.95
MW-9	14.30	9/1/98	9.78	4.52
		11/24/98	8.00	6.30
		2/24/99	6.76	7.54
		5/18/99	7.69	6.61
MW-10	14.97	9/1/98	10.42	4.55
		11/24/98	9.69	5.28
		2/24/99	7.40	7.57
		5/18/99	8.43	6.54

ft amsl = Feet above mean sea level
ft bmp = Feet below measuring point

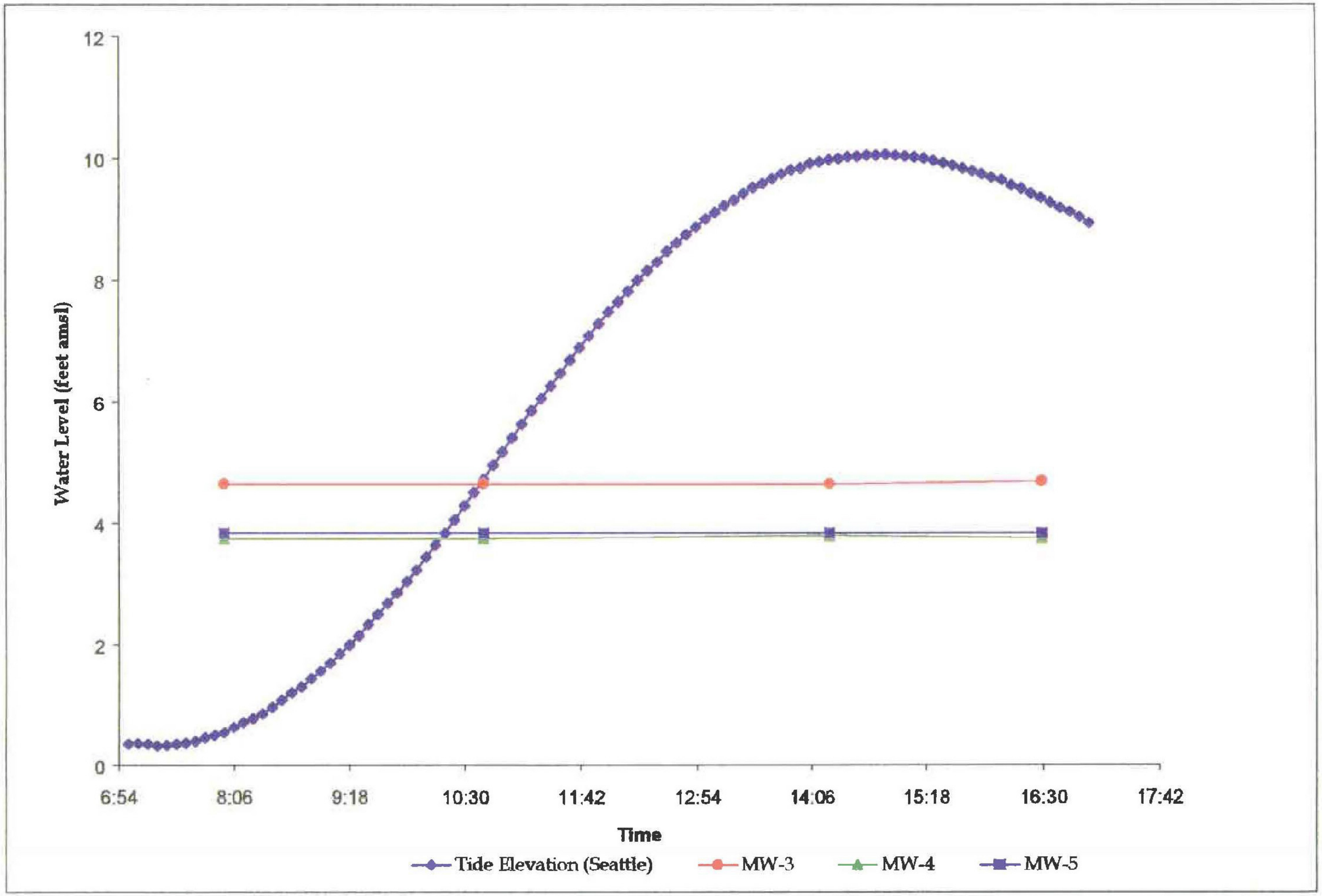

FIGURE 5-1

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TIDAL FLUCTUATION AND WATER LEVELS
IN MONITORING WELLS, 2 SEPTEMBER 1998

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

FINAL

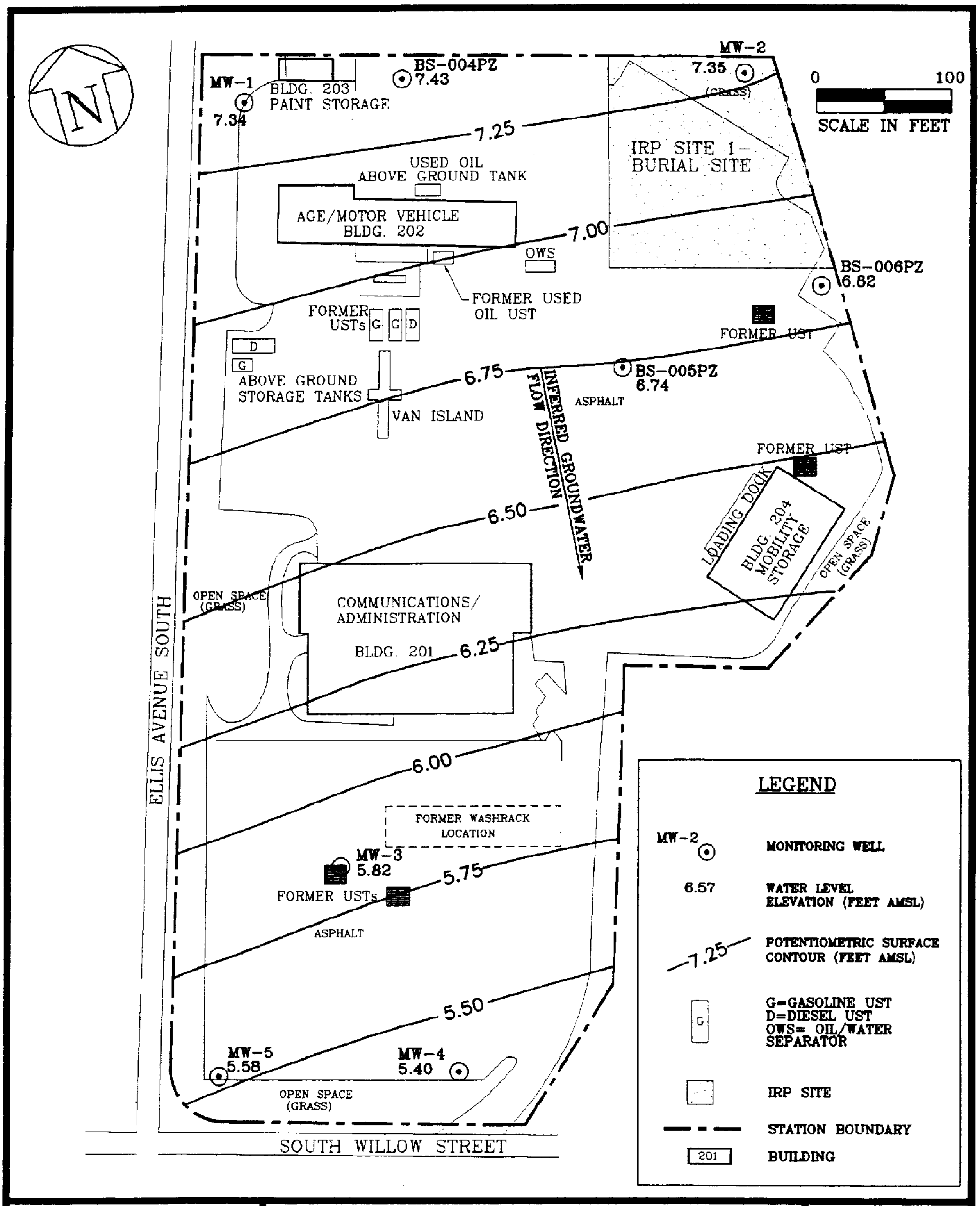

FIGURE 5-2

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POTENTIOMETRIC SURFACE
10-11 APRIL 1997

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

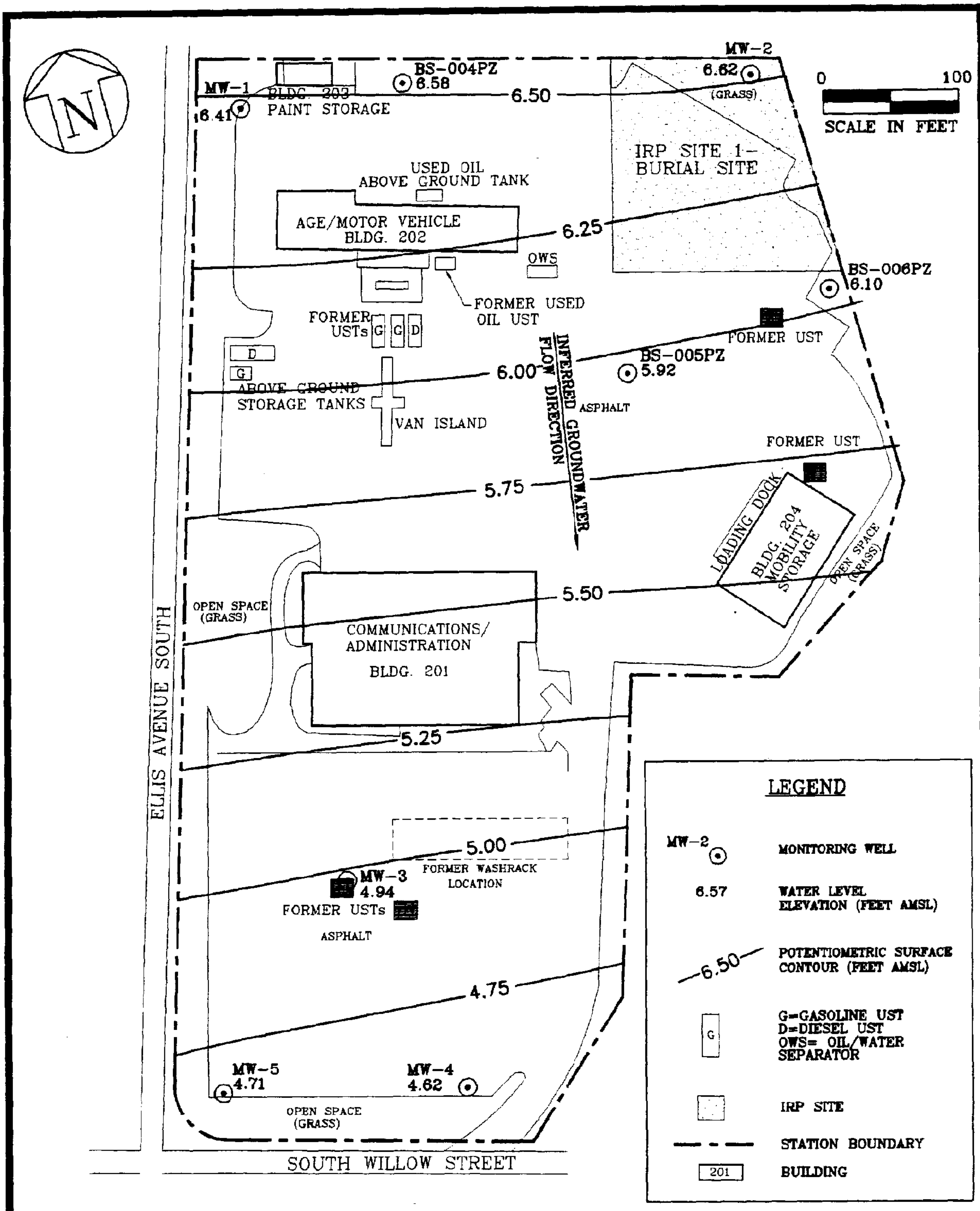

FIGURE 5-3

POTENTIOMETRIC SURFACE
10-11 JULY 1997

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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SEA407863

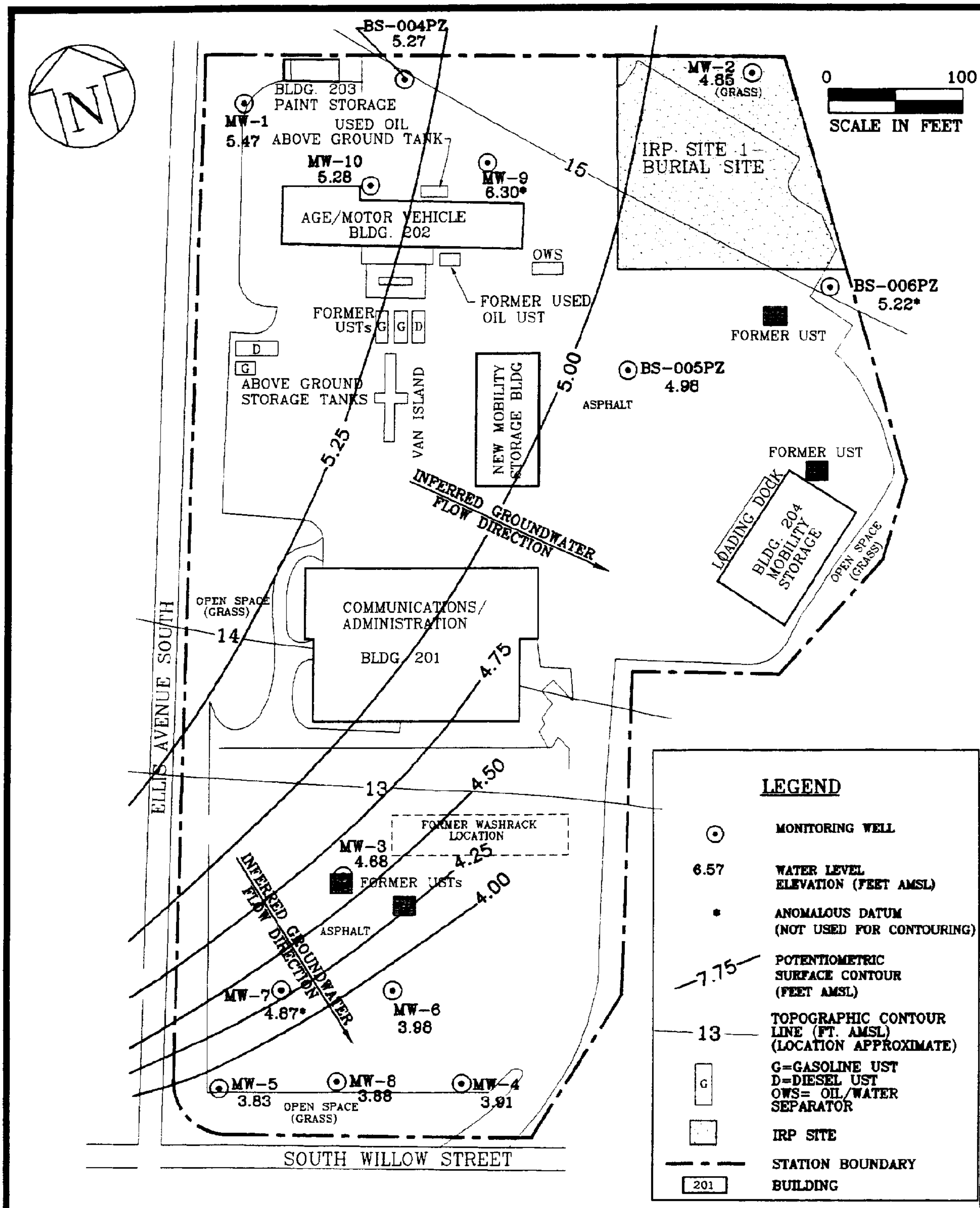

FIGURE 5-4	POTENTIOMETRIC SURFACE 24 NOVEMBER 1998 143rd CCS, Seattle ANGS Seattle, Washington	ERM

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SEA407864

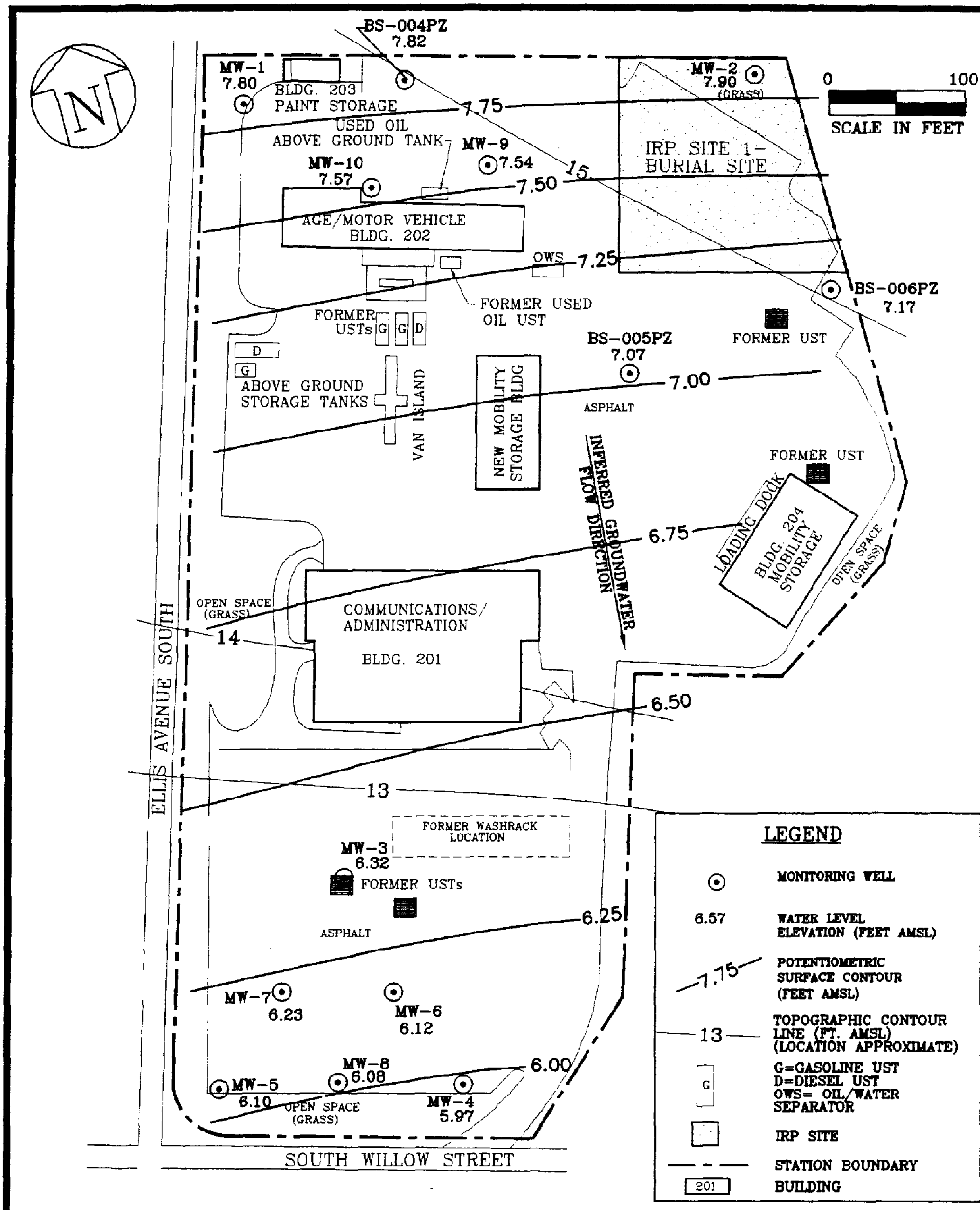

FIGURE 5-5

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POTENTIOMETRIC SURFACE
24 FEBRUARY 1999

143rd CCS, Seattle ANGS
Seattle, Washington

ERM

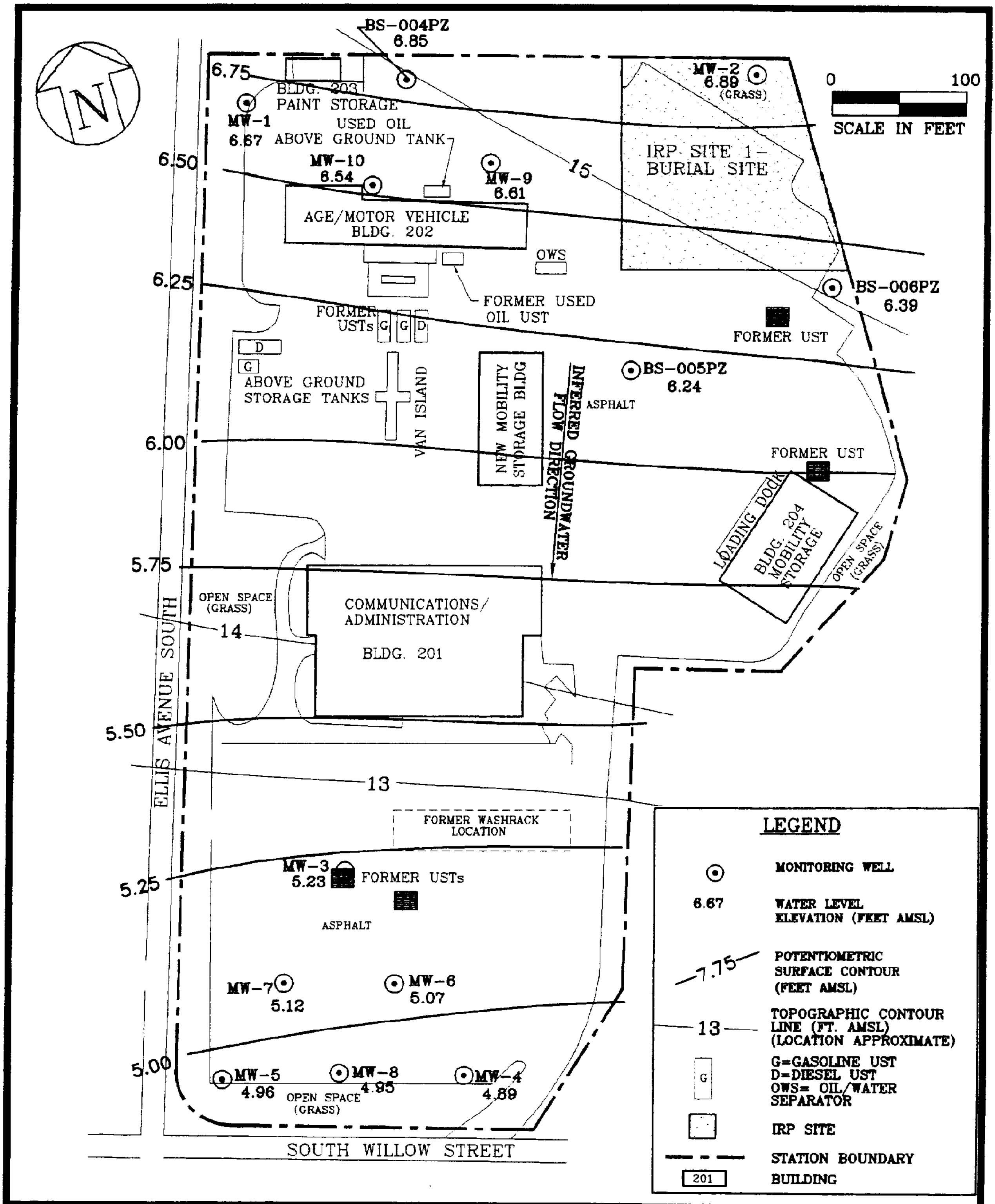

FIGURE 5-6

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POTENTIOMETRIC SURFACE
18 MAY 1999

143rd CCS, Seattle ANGS
Seattle, Washington

ERM

As part of the Phase I RI, slug tests were performed on monitoring well MW-3 to evaluate the hydraulic conductivity of the shallow groundwater-bearing unit at the site. Estimates for the hydraulic conductivity proximal to monitoring well MW-3, calculated using the Bouwer and Rice method of analysis, ranged from 1.25×10^{-4} to 6.09×10^{-4} feet per second (3.29 to 16.04 meters per day). These relatively high values for hydraulic conductivity are consistent with the predominant sand lithology observed at the Station, and provide an explanation for the observed rapid response of groundwater elevations to seasonal fluctuations in precipitation. Slug test data are presented in the Phase I RI Report (ERM 1998a).

5.2 Project Screening Goals

Numeric project screening goals (PSGs) were developed during the Phase I RI for constituents that were detected in background and site-characterization soil and groundwater samples. The PSGs were derived from chemical-specific ARARs and were used to evaluate detected constituent concentrations for compliance with applicable regulatory criteria. The PSGs developed during Phase I also were used to evaluate the concentrations of constituents detected during the Phase II RI.

The PSGs used for this project and the numeric ARARs from which they were derived are summarized on Tables 5-2 and 5-3. The PSGs were derived according to the following criteria:

Soil PSGs

1. The MTCA Method A Table Value (Residential Soil Cleanup Level; Washington Administrative Code [WAC] 173-340-740[2]) was used as the initial PSG.

2. If there was no MTCA Method A Table Value available, the MTCA Method B Formula Value (WAC 173-340-740[3]; WDOE 1994a) was used as the initial PSG (cancer or non-cancer value, whichever was more stringent).

3. The regional natural background concentration (WDOE 1994b) was used if there was no MTCA Method A or Method B value available, or if the MTCA Method A (or Method B) value was less than the natural background concentration.

TABLE 5-2
Numeric ARARs and Project Screening Goals for Constituents Detected in Soil
143rd CCSQ, Seattle ANGS, Seattle, Washington

Analyte	MTCA Method A Table Value (Residential Soil)	MTCA Method A Table Value (Industrial Soil)	MTCA Method B Cancer Formula Value	MTCA Method B Non-Cancer Formula Value	Regional Natural Background Concentration	Site-Specific Background Concentration*	Project Screening Goal
Organic Compounds: (mg/kg)							
Bis(2-ethylhexyl)phthalate	--	--	71.4	1,600	--	ND	71.4
TPH-Gasoline	100	100	--	--	--	ND	100
TPH-Diesel	200	200	--	--	--	ND	200
TPH-Heavy oil	200	200	--	--	--	ND	200
Trichloroethene	0.5	0.5	90.9	--	--	ND	0.5
Radionuclides: (pCi/g)							
Gross Alpha	--	--	--	--	--	9.96	9.96
Gross Beta	--	--	--	--	--	16.1	16.1
Radium-226	--	--	--	--	--	0.77	0.77
Radium-228	--	--	--	--	--	0.93	0.93
Metals: (mg/kg)							
Arsenic	20	200	1.43	60	7.3	5.59	20
Cadmium	2	10	0.164	80	0.77	ND	2
Chromium	100	500	--	--	48.15	14.2	100
Copper	--	--	--	2,960	36.36	15.8	2,960
Lead	250	1,000	--	--	16.83	18.2	250
Nickel	--	--	--	1,600	38.19	10.5	1,600
Selenium	--	--	--	400	--	1.66	400
Zinc	--	--	--	24,000	85.06	30.1	24,000

mg/kg = Milligrams per kilogram
pCi/g = PicoCuries per gram
MTCA = Model Toxics Control Act
-- = Standard not established/value not available
* Site-specific background concentration corresponds to the 95% upper confidence limit (UCL) mean concentration in RI background samples.
ND = Compound not detected in RI background samples.
Sources:
MTCA Method A Table Values: WAC 173-340-740 (Table 2) and WAC 173-340-745 (Table 3), MTCA Method A Cleanup Levels for Soil
MTCA Method B Formula Values: MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, 1995
Regional Natural Background Concentrations: Natural Background Soil Metals Concentrations in Washington State, October 1994 (Washington State Department of Ecology Publication 94-115), Table 17, Puget Sound 90th percentile values.

TABLE 5-3

Numeric ARARs and Project Screening Goals for Constituents Detected in Groundwater
143rd CCSQ, Seattle ANGS, Seattle, Washington

Analyte	MTCA Method A Table Value	Federal Primary MCL	Federal Secondary MCL	MTCA Method B Cancer Formula Value	MTCA Method B Non-Cancer Formula Value	Site-Specific Background Concentration*	Project Screening Goal
Organic Compounds: (µg/l)							
Acetone	--	--	--	--	800	ND	800
Benzene	5	5	--	1.51	--	ND	5
1,1-Dichloroethane	--	--	--	--	800	0.513	800
1,2-Dichloroethane	5	5	--	0.481	--	ND	5
cis-1, 2-Dichloroethene	--	70	--	--	80	ND	70
Ethylbenzene	30	700	--	--	800	ND	30
Tetrachloroethene	5	5	--	0.858	80	7.33	5
Toluene	40	1,000	--	--	1,600	1.04	40
1,1,1-Trichloroethane	200	200	--	--	7,200	2.63	200
Trichloroethene	5	5	--	3.98	--	ND	5
1,3,5-Trimethylbenzene	--	--	--	--	--	0.507	0.507
Xylenes	20	10,000	--	--	16,000	ND	20
Radionuclides:							
Gross Alpha	15 pCi/l	15 pCi/l	--	--	--	1.89 pCi/l	15 pCi/l
Gross Beta	4 mrem/yr	4 mrem/yr	--	--	--	11.3 pCi/l	11.3 pCi/l (1)
Radium-226	3 pCi/l	--	--	--	--	0.236 pCi/l	3pCi/l
Radium-226 and 228	5 pCi/l	5 pCi/l	--	--	--	0.494 pCi/l	5 pCi/l
Radium-228	2 pCi/l (2)	--	--	--	--	0.258 pCi/l	2 pCi/l
Metals: (µg/l)							
Arsenic	5	50	--	0.05	4.8	ND	5
Copper	--	--	1,000	--	592	8.06	1,000
Nickel	--	100	--	--	320	9.66	100
Zinc	--	--	5,000	--	4,800	51	5,000

µg/l = Micrograms per liter
pCi/l = PicoCuries per liter
mrem/yr = Millirem per year
-- = Standard not established
MTCA = Model Toxics Control Act
MCL = Maximum Contaminant Level (Enforceable Level) for drinking water
ND = Compound not detected in RI background samples.
(1) = The site-specific background concentration for gross beta radiation was chosen as the Project Screening Goal rather than the MTCA Method A Table Value because laboratory results were reported as concentrations, not dosages. The MTCA Method A Table Value is given as a dosage, and is thus not as easily compared with sample results.
(2) = MTCA Method A Tables for groundwater report a combined Radium-226 and Radium-228 cleanup level of 5 piC/l. The cleanup level for Radium-226 alone is 3 piC/l. Therefore, the cleanup level for Radium-228 alone is approximated at 2 piC/l.
*Site-specific background concentration corresponds to the 95% upper confidence limit (UCL) mean concentration in RI background samples.
Sources: MTCA Method A Table Values: WAC 173-340-720, MTCA Method A Cleanup Levels for Groundwater
MTCA Method B Formula Values: MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, 1995
Primary and Secondary MCLs: 40 Code of Federal Regulations 141.11-16, 141.60-63, and 143.3

4. If there was no MTCA Method A, MTCA Method B, or natural background concentration value available, the site-specific background concentration (95 percent upper confidence limit [UCL] mean concentration; Table 5-2) was used.

Groundwater PSGs

1. The MTCA Method A Table Value (Groundwater Cleanup Level; WAC 173-340-720[2]) or the Federal Safe Drinking Water Act Primary MCL or Secondary Maximum Contaminant Level (SMCL) (40 Code of Federal Regulations [CFR] 141.11-16, 141.60-63, and 143.3) was used, whichever was more stringent.

2. If there was no MTCA Method A Table Value or MCL/SMCL available, the MTCA Method B Formula Value (WAC 173-340-720[3]; WDOE 1994a) was used (cancer or non-cancer value, whichever was more stringent).

3. If there was no MTCA Method A, MCL/SMCL, or MTCA Method B value available, the site-specific background concentration (95 percent UCL mean concentration; Table 5-3) was used (data on regional natural background concentrations were not available for the constituents detected).

5.3 Installation-Wide Background Sampling Results

Site-specific background soil and groundwater samples were collected during the Phase I RI. The results of the Phase I RI background sampling are presented on Tables 2-6 and 2-8 and in the Phase I RI Report (ERM 1998a).

Background groundwater samples were collected from monitoring wells MW-1 and BS-004PZ during Phase I. PCE was detected above PSGs in monitoring well BS-004PZ; the highest concentration of PCE detected in this well was 17 µg/l. Wells MW-1 and BS-004PZ were included in the Phase II groundwater monitoring program; analytical testing results for these wells are presented in Section 5.4.4.

5.4 Installation-Wide Findings

This section presents the field-screening and analytical testing results for the soil vapor, soil, and groundwater samples collected at the Seattle ANGS during the Phase II RI. The repositories of laboratory analytical data packages are listed in Appendix E.

5.4.1 Screening Results

Soil samples were field-screened for organic vapors using a PID. The results of the organic vapor screening are documented on the borehole logs contained in Appendix B.

5.4.2 Soil Vapor

Soil vapor samples were collected from 40 locations at a depth of approximately 5 feet bgs. The soil vapor samples were analyzed for VOCs in a mobile field laboratory using USEPA Method 8021B. Constituents detected in the soil vapor samples are presented on Figure 5-7. The results of the soil vapor survey were used to select the final StrataProbe soil and groundwater sampling locations.

Constituents detected in the soil vapor samples include TCE, PCE, carbon tetrachloride, benzene, toluene, ethylbenzene, and xylenes. Detected concentrations of these constituents were relatively low; the highest concentration detected was 5.5 parts per million (total xylenes, at sampling point SVS-27). The low concentrations and diffuse spatial distribution of the detected constituents suggest that there are no areas of significant VOC contamination in shallow soils at the Seattle ANGS.

5.4.3 Soils

Soil samples were collected from 20 direct-push borings (GP-23 through GP-42) and 5 monitoring well borings (MW-6 through MW-10) installed during Phase II, at depths between 5 and 10 feet bgs. The soil samples were analyzed for VOCs at an off-site State-certified laboratory using USEPA Method 8260. Additionally, samples collected from borings GP-23, GP-24, and GP-25 were analyzed for TPH using Washington Method WTPH-HCID to assess the lateral extent of TPH in soil

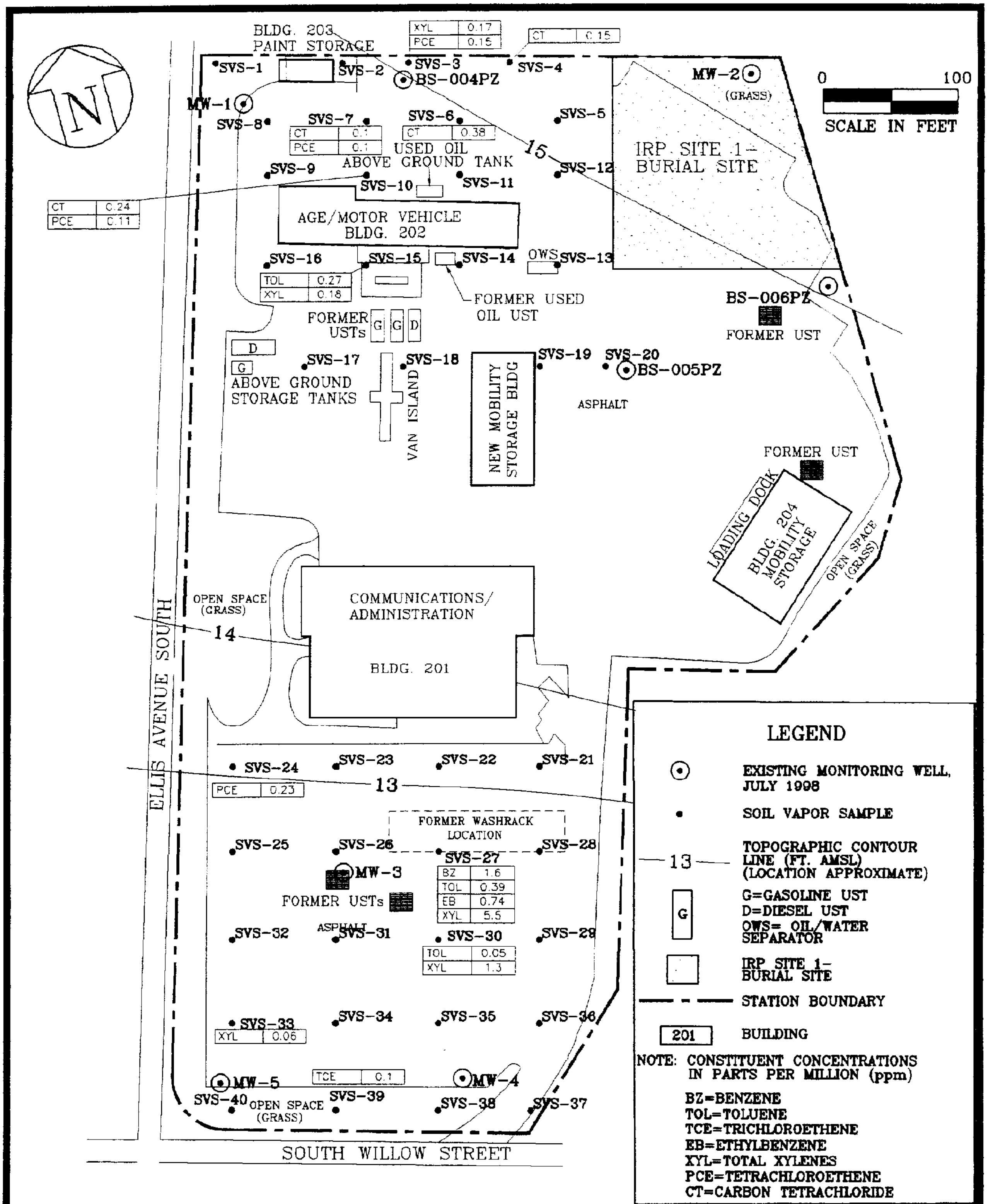

FIGURE 5-7

CONSTITUENTS DETECTED IN SOIL VAPOR SAMPLES

143rd CCS, Seattle ANGS
Seattle, Washington

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SEA407872

surrounding PA/SI boring BS-003BH. The results of the soil sampling are discussed below.

5.4.3.1 Volatile Organic Compounds

Xylenes were detected at a concentration below the associated PSG in the soil sample collected from 7 feet bgs at boring GP-39. No other VOCs were detected in the soil samples collected during the Phase II RI.

5.4.3.2 Total Petroleum Hydrocarbons

No petroleum hydrocarbons were detected in the soil samples collected from borings GP-23, GP-24, and GP-25.

5.4.4 Groundwater

Groundwater samples were collected from the 20 direct-push (StrataProbe) borings installed during Phase II (GP-23 through GP-42). In addition, the site's 13 groundwater monitoring wells were sampled on a quarterly basis. The StrataProbe groundwater samples were analyzed for VOCs in a mobile field laboratory using USEPA Method 8021B. The samples collected from monitoring wells were analyzed for VOCs at an off-site State-certified laboratory using USEPA Method 8260.

Constituents detected in the Phase II StrataProbe groundwater samples are summarized on Table 5-4 and depicted on Figure 5-8. Table 5-5 summarizes the organic constituents detected in groundwater monitoring wells during the RI. Concentrations of COPCs that exceeded PSGs in direct-push and monitoring-well groundwater samples collected during the RI are displayed on Figure 5-9.

VOCs detected in the StrataProbe groundwater samples include cis-1,2-dichloroethene, TCE, and PCE. The concentrations of TCE detected at locations GP-36 and GP-38 (10 and 25 μg/l, respectively) exceed the MTCA Method A Cleanup Level of 5 μg/l.

Samples collected from background (upgradient) well BS-004PZ in January 1997, April 1997, and May 1999 contained PCE concentrations above the MTCA Method A Cleanup Level of 5 μg/l; the maximum concentration detected was 17 μg/l. PCE also was detected in background well MW-1 in February 1999, at a concentration of 5.2 μg/l. TCE was detected at concentrations above the MTCA Method A Cleanup Level of 5 μg/l in February 1999 in monitoring well MW-8 (83 μg/l), and in wells MW-6 and MW-8 in May 1999 (5.7 and 19 μg/l, respectively).

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TABLE 5-4

Constituents Detected in StrataProbe Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Cis-1,2-Dichloroethene	Trichloroethene	Tetrachloroethene
GP-33	8/12/98	ND	ND	2
GP-34	8/12/98	3	ND	ND
GP-36	8/12/98	5	**10**	ND
GP-37	8/12/98	ND	1	ND
GP-38	8/12/98	26	**25**	ND
	Project Screening Goal	70	5	5

All concentrations in micrograms per liter (µg/l).
ND = Not detected above laboratory method reporting limit
Shaded cells indicate a detection above the associated project screening goal.
Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.

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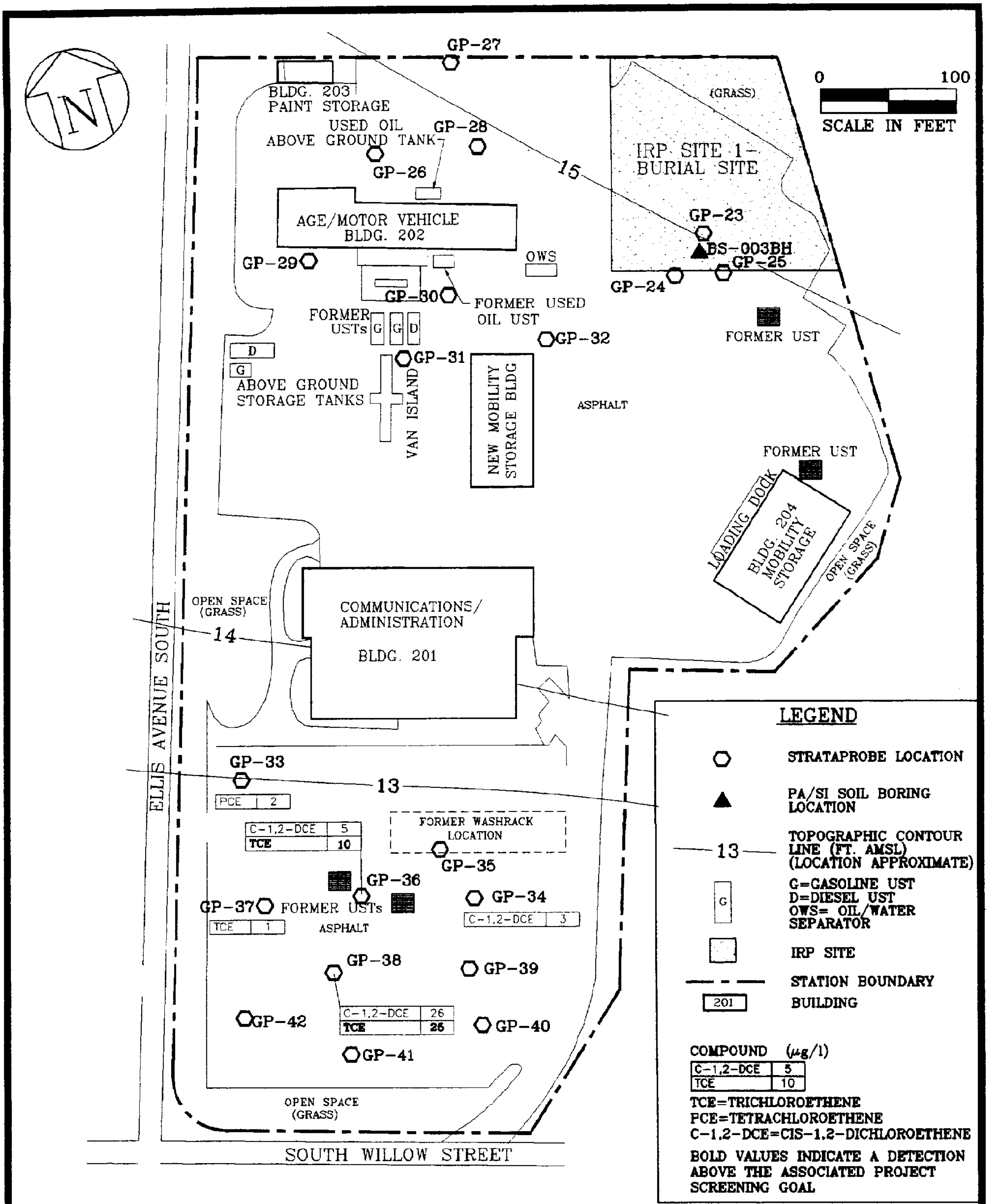

FIGURE 5-8

CONSTITUENTS DETECTED IN
STRATAPROBE GROUNDWATER SAMPLES

143rd CCSQ, Seattle ANGS
Seattle, Washington

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TABLE 5-5

Organic Constituents Detected in Groundwater Monitoring Wells
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Acetone	Toluene	1,1-Dichloroethane	1,1,1-Trichloroethane	Cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene	Trichloroethene	Tetrachloroethene
BS-004PZ (Background Well)	9/17/96	ND	(ND)	0.3	3.7	ND	ND	ND	3.8
	9/17/96 (dup)	ND	(ND)	0.3	3.8	ND	ND	ND	3.8
	1/14/97	ND	ND	ND	2.4	ND	ND	ND	**5.1**
	4/11/97	ND	ND	ND	3.3	ND	ND	ND	**17**
	7/10/97	ND	ND	ND	1.8	ND	ND	ND	(ND)
	9/2/98	ND	ND	ND	ND	ND	ND	ND	2.0
	11/25/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/19/99	ND	ND	ND	ND	ND	ND	ND	**6.8**
BS-005PZ	9/17/96	ND	ND	ND	ND	ND	0.2	ND	ND
	1/15/97	ND	ND	ND	ND	ND	ND	ND	ND
	4/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	7/11/97	ND	ND	ND	ND	ND	ND	ND	4.7
	9/1/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/25/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	ND	ND	ND	ND	ND
BS-006PZ	9/17/96	ND	ND	ND	ND	ND	0.2	ND	ND
	1/14/97	ND	ND	ND	ND	ND	ND	ND	ND
	4/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	7/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	9/2/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/24/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	ND	ND	ND	ND	ND
MW-1 (Background Well)	10/18/96	ND	ND	ND	ND	ND	ND	ND	ND
	12/17/96	ND	ND	ND	ND	ND	ND	ND	ND
	1/14/97	ND	1.1	ND	ND	ND	ND	ND	ND
	4/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	7/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	9/1/98	ND	6.0	ND	ND	ND	ND	ND	ND
	11/25/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	**5.2**
	5/19/99	ND	ND	ND	ND	ND	ND	ND	ND
MW-2	10/18/96	ND	ND	ND	ND	ND	ND	ND	ND
	12/17/96	ND	ND	ND	ND	ND	ND	ND	ND
	1/15/97	ND	ND	ND	ND	ND	ND	ND	ND
	1/15/97 (dup)	ND	ND	ND	ND	ND	ND	ND	ND
	4/10/97	ND	ND	ND	ND	ND	ND	ND	ND
	7/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	9/2/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/25/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	ND	ND	ND	ND	ND
MW-3	10/18/96	18	ND	ND	ND	ND	ND	ND	ND
	10/18/96 (dup)	20	ND	ND	ND	ND	ND	ND	ND
	12/17/96	ND	ND	ND	ND	ND	ND	ND	ND
	12/17/96 (dup)	ND	ND	ND	ND	ND	ND	ND	ND
	1/15/97	ND	ND	ND	ND	ND	ND	ND	ND
	4/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	7/11/97	ND	ND	ND	ND	ND	ND	ND	ND
	9/2/98	ND	ND	ND	ND	ND	ND	ND	ND
	9/2/98 (dup)	ND	ND	ND	ND	ND	ND	ND	ND
	11/24/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/24/98 (dup)	ND	ND	ND	ND	ND	ND	ND	ND
	2/25/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5-5

Organic Constituents Detected in Groundwater Monitoring Wells
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Acetone	Toluene	1,1-Dichloroethane	1,1,1-Trichloroethane	Cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene	Trichloroethene	Tetrachloroethene
MW-4	10/18/96	11	ND	ND	ND	ND	ND	3.9	ND
	12/17/96	ND	ND	ND	ND	ND	ND	2.7	ND
	1/14/97	ND	ND	ND	ND	ND	ND	3.4	ND
	4/11/97	ND	ND	ND	ND	ND	ND	3.2	ND
	7/11/97	ND	ND	ND	ND	ND	ND	2.8	ND
	9/2/98	ND	ND	ND	ND	ND	ND	2.0	ND
	11/24/98	ND	ND	ND	ND	ND	ND	3.4	ND
	2/24/99	ND	ND	ND	ND	ND	ND	2.6	ND
	2/24/99 (dup)	ND	ND	ND	ND	ND	ND	2.6	ND
	5/18/99	ND	ND	ND	ND	ND	ND	2.9	ND
MW-5	10/18/96	ND	ND	ND	ND	5.6	ND	ND	ND
	12/17/96	ND	ND	ND	ND	4.9	ND	ND	ND
	1/14/97	ND	ND	ND	ND	2.7	ND	ND	ND
	4/11/97	ND	ND	ND	ND	1.4	ND	ND	ND
	4/11/97 (dup)	ND	ND	ND	ND	1.6	ND	ND	ND
	7/10/97	ND	ND	ND	ND	3.5	ND	2.1	(ND)
	7/10/97 (dup)	ND	ND	ND	ND	2.8	ND	ND	ND
	9/2/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/24/98	ND	ND	ND	ND	3.2	ND	ND	ND
	2/25/99	ND	ND	ND	ND	1.7	ND	ND	ND
	5/18/99	ND	ND	ND	ND	ND	ND	ND	ND
MW-6	9/2/98	ND	ND	ND	ND	ND	ND	3.0	ND
	11/24/98	ND	ND	ND	ND	ND	ND	3.0	ND
	2/25/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	ND	1.0	ND	**5.7**	ND
MW-7	9/2/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/24/98	ND	ND	ND	ND	ND	ND	3.8	ND
	2/25/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	ND	ND	ND	ND	ND
MW-8	9/2/98	ND	ND	ND	ND	ND	ND	3.0	ND
	11/24/98	ND	ND	ND	ND	ND	ND	3.3	ND
	2/24/99	ND	ND	ND	ND	39	ND	**83**	ND
	2/24/99 (dup)	ND	ND	ND	ND	42	ND	**87**	ND
	5/18/99	ND	ND	ND	ND	4.5	ND	**19**	ND
	5/18/99 (dup)	ND	ND	ND	ND	4.7	ND	**21**	ND
MW-9	9/1/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/24/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/18/99	ND	ND	ND	1.4	ND	ND	ND	1.8
MW-10	9/1/98	ND	ND	ND	ND	ND	ND	ND	ND
	11/25/98	ND	ND	ND	ND	ND	ND	ND	ND
	2/24/99	ND	ND	ND	ND	ND	ND	ND	ND
	5/19/99	ND	ND	ND	ND	ND	ND	ND	ND
RI Project Screening Goal		800	40	800	200	70	0.507	5.0	5.0

Notes:

All concentrations in micrograms per liter (μg/l)

ND = Not detected above laboratory method reporting limit

(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).

dup = Duplicate sample

RI = Remedial Investigation

Shaded cell/bold typeface indicates a value exceeding the associated RI project screening goal.

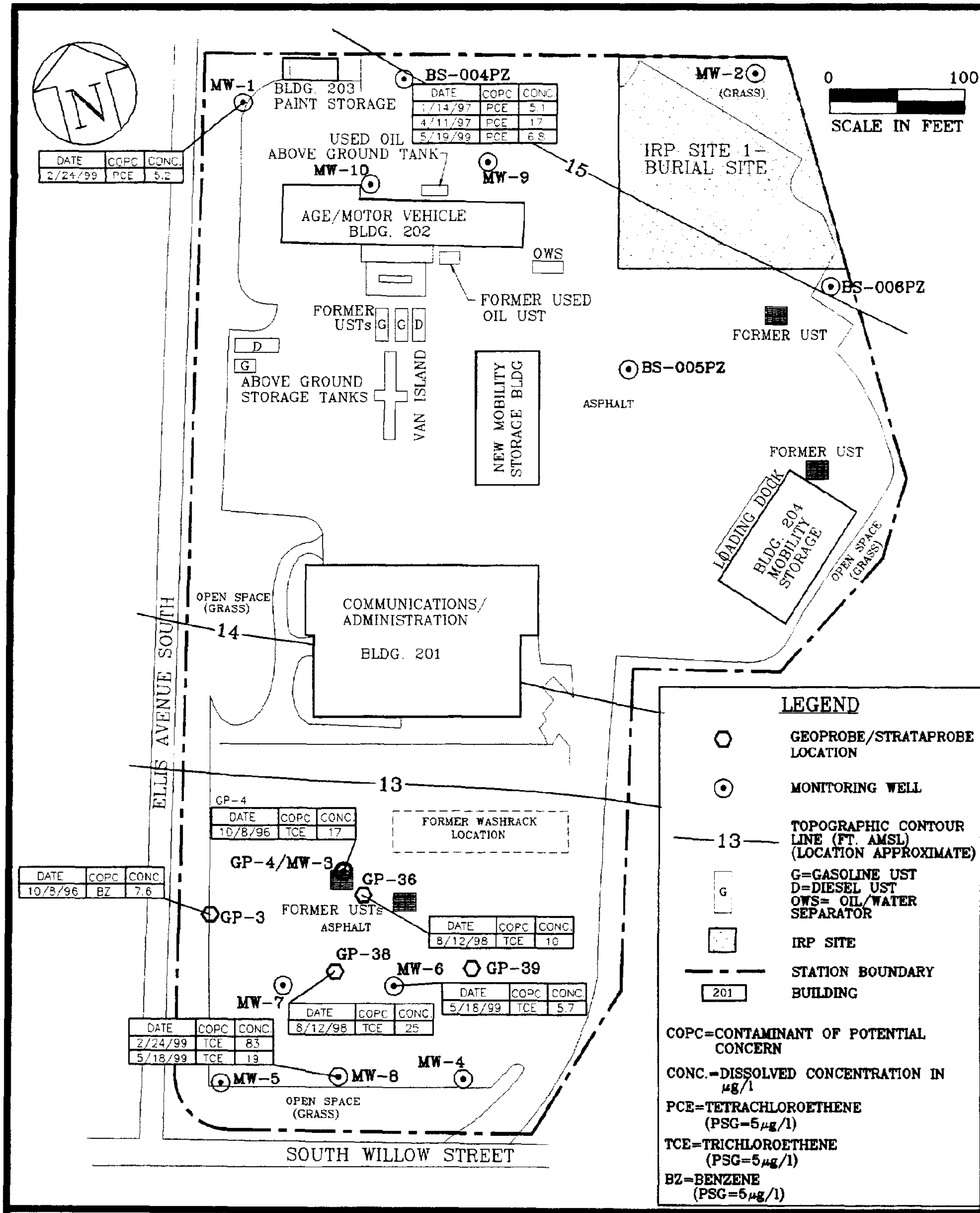

FIGURE 5-9

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DETECTIONS OF COPCs ABOVE PROJECT SCREENING GOALS IN GROUNDWATER
143rd CCS, Seattle ANGS
Seattle, Washington

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5.5 Field Quality Assurance/Quality Control Sample Results

Field blank and equipment rinsate blank samples collected during Phase II were analyzed for the same parameters as the associated project samples. Trip blanks were analyzed for VOCs only. The analytical results for the QC blank samples are summarized on Table 5-6. Acetone, bromodichloromethane, chloroform, and methylene chloride were detected in select QC blanks. None of these constituents were detected in the associated project samples.

5.6 Analytical Data Review and Validation Results

The laboratory analytical data generated during the Phase II RI were reviewed by a qualified analytical chemist for conformance with the project data quality objectives specified in the Phase II RI/FS Work Plan (ERM 1998b). In addition, approximately ten percent of the soil analytical data and 100 percent of the groundwater data were validated in accordance with *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (February 1994). Appendix F contains the QC data review/validation reports for the Phase II RI.

Some of the quantitation limits and positive detections reported by the laboratory for selected samples were qualified as estimated values or tentative identifications based on the data review and validation. The data qualification actions are the result of typical minor analytical accuracy and precision anomalies, and are not considered cause for further action. None of the Phase II analytical data were rejected. Accordingly, the analytical data are of acceptable quality and can be used for decision-making purposes.

5.7 Summary and Conclusions

This section provides a summary and conclusions regarding the Phase II RI sampling results for the Seattle ANGS. Relevant data from the Phase I RI are included in the discussion to provide a comprehensive review of the RI site characterization results.

TABLE 5-6

Analytical Results for Phase II RI Field Quality Control Blank Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Type	Date	Sample Number	Volatile Organic Compounds			
			Acetone	Bromo-dichloromethane	Chloroform	Methylene Chloride
Field Blank (Tap Water)	7/28/98	SVS-15FT	ND	ND	ND	ND
Field Blank (ASTM Type II Water)	7/28/98	SVS-15FA	ND	ND	ND	ND
Rinsate Blank	7/28/98	SVS-5R	ND	ND	ND	ND
Rinsate Blank	7/28/98	SVS-15R	ND	ND	ND	ND
Trip Blank	7/28/98	TB072898-1	ND	ND	ND	ND
Rinsate Blank	7/29/98	SVS-25R	ND	ND	ND	ND
Rinsate Blank	7/29/98	SVS-35R	ND	ND	ND	ND
Trip Blank	7/29/98	TB072998-1	ND	ND	ND	ND
Rinsate Blank	8/12/98	GP-36R	ND	ND	ND	ND
Trip Blank	8/12/98	TB081298-1	ND	ND	ND	ND
Field Blank (Tap Water)	8/13/98	GP-24FT	ND	ND	11	ND
Field Blank (ASTM Type II Water)	8/13/98	GP-24FA	ND	ND	ND	ND
Rinsate Blank	8/13/98	GP-24R	ND	ND	ND	ND
Rinsate Blank	8/13/98	GP-26R	ND	ND	ND	ND
Trip Blank	8/13/98	TB081398-1	ND	ND	ND	ND
Rinsate Blank	8/27/98	MW-8-6.5R	ND	ND	5	ND
Trip Blank	8/27/98	TB082798-1	ND	1	28	6
Trip Blank	9/1/98	TB090198	ND	ND	ND	ND
Field Blank (Tap Water)	9/2/98	BS-004PZ-98-1FT	ND	ND	18	ND
Field Blank (ASTM Type II Water)	9/2/98	BS-004PZ-98-1FA	ND	ND	ND	ND
Rinsate Blank	9/2/98	MW-3-98-1RB	ND	ND	ND	ND
Trip Blank	9/2/98	TB090298	ND	ND	ND	ND
Rinsate Blank	11/24/98	MW-3-98-2R	ND	ND	ND	ND
Trip Blank	11/24/98	TB112498-1	ND	ND	ND	ND
Field Blank (Tap Water)	11/25/98	BS-004PZ-98-2FT	ND	1.8	36	ND
Field Blank (ASTM Type II Water)	11/25/98	BS-004PZ-98-2FA	ND	ND	ND	ND
Field Blank (Tap Water)	2/24/99	MW-8-99-1FT	ND	ND	ND	ND
Field Blank (ASTM Type II Water)	2/24/99	MW-8-99-1FA	ND	ND	ND	ND
Rinsate Blank	2/24/99	MW-4-99-1R	ND	ND	ND	ND
Trip Blank	2/24/99	TB022499-1	ND	ND	ND	ND
Trip Blank	2/25/99	TB022599-1	ND	ND	ND	ND
Field Blank (Tap Water)	5/18/99	MW-8-99-2FT	ND	1.4	22	ND
Field Blank (ASTM Type II Water)	5/18/99	MW-8-99-2FA	23	ND	ND	ND
Rinsate Blank	5/18/99	MW-4-99-2R	23	ND	ND	ND
Trip Blank	5/18/99	TB051899-1	ND	ND	ND	ND

All concentrations in micrograms per liter (μg/l)
ASTM = American Society for Testing and Materials
ND = Not detected above laboratory method reporting limit

COPCs identified during the RI include any constituents detected above method reporting limits that cannot be attributed to area background concentrations or sampling/laboratory contamination. COPCs detected above PSGs at the Seattle ANGS during the Phase I and II RI include benzene, TCE, and PCE in groundwater. Detections of these constituents that exceeded PSGs are shown on Figure 5-9. The PSG for each of these constituents was 5 µg/l, which is the MTCA Method A Cleanup Level for each constituent.

Benzene was detected above the PSG in one direct-push groundwater sample collected in the southern portion of the Station. TCE was detected above the PSG in three direct-push groundwater samples and three samples collected from monitoring wells (MW-6 and MW-8) in the southern portion of the Station. PCE was detected above the PSG in three groundwater samples collected from background monitoring well BS-004PZ, and in one sample collected from background well MW-1.

Despite extensive sampling of soil and groundwater at the Seattle ANGS during the Phase I and II RI, the source of the VOCs in groundwater has not been identified. TCE has been detected in a number of shallow groundwater monitoring wells at the Boeing site immediately south of the Station, at concentrations up to 1,000 µg/l (Boeing 1998). The groundwater data for this site (identified as North Boeing Field Site 6 on Figure 2-2) define a dissolved TCE plume extending from near the north end of the site to properties off-site to the south; the highest concentrations were detected near the middle of the site. Because the Boeing site is hydraulically downgradient of the Seattle ANGS, the observed TCE concentrations at the Seattle ANGS likely cannot be explained by advective transport of TCE from the Boeing site (i.e., spreading of the Boeing TCE plume via bulk groundwater flow). However, dispersion of the Boeing plume at the plume's upgradient edge (via concentration-driven diffusion, for example) may be at least partially responsible for the TCE detected in groundwater at the Seattle ANGS.

StrataProbe borings GP-23, GP-24, and GP-25 were installed to determine the lateral extent of petroleum hydrocarbons in soil surrounding PA/SI boring BS-003BH. Positive detections of TPH were reported in soil samples collected from approximately 3 and 6 feet bgs in boring BS-003BH, at concentrations of 780 and 160 milligrams per kilogram (mg/kg), respectively (see Table 2-1; OpTech 1995). However, these results were obtained using USEPA Method 418.1; analysis of the same two soil samples for diesel- and gasoline-range hydrocarbons using Washington Methods WTPH-D and WTPH-G yielded "non-detectable" (ND) results (OpTech 1995). This fact, combined with the fact that TPH was not detected in the StrataProbe soil samples collected in this area, suggests that the reported TPH detections in the PA/SI samples may have been false detections caused by matrix interference or laboratory error. Alternatively, if the TPH detections in the PA/SI soil samples were real, the hydrocarbons are likely long-chain compounds (i.e., >C24) confined to shallow soil beneath the asphalt pavement in the immediate vicinity of boring BS-003BH, and thus do not pose a threat to human health or the environment. TPH was analyzed for but was not detected in groundwater samples collected during the Phase I RI.

SECTION 6.0

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a preliminary summary of Federal and State ARARs that may be relevant to FS development or other IRP activities at the Seattle ANGS. ARARs will be further evaluated as necessary during the Phase II FS.

6.1 Federal Requirements

6.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

Section 121 (d) of CERCLA, as amended by SARA, addresses the management of Federal facilities. The IRP has been designed to mirror site investigation requirements under CERCLA (i.e., PA, SI, RI, FS, RD, and RA).

6.1.2 Resource Conservation and Recovery Act

Resource Conservation and Recovery Act (RCRA) regulations governing hazardous waste management provide both action- and chemical-specific ARARs that may apply to IRP activities at the Station.

6.1.2.1 Waste Identification

Waste materials generated at the site (e.g., drill cuttings, purge water, decontamination water) are regulated as hazardous waste if they meet the Federal definition provided in 40 Code of Federal Regulations (CFR) 261.

6.1.2.2 Waste Generation and Transport

RI activities or remedial alternatives involving the generation or transport of hazardous waste trigger RCRA hazardous waste generator requirements provided in 40 CFR 262. When hazardous waste is shipped off site in regulated amounts, the manifesting and transport procedures in 40 CFR 263 must be followed.

6.1.2.3 Land Disposal Restrictions

RCRA regulations in 40 CFR 268 set forth Land Disposal Restrictions (also known as Land Ban Requirements) for RCRA wastes. These restrictions were required by the Hazardous and Solid Waste Amendments of 1984 to RCRA to prohibit the continued land disposal of hazardous wastes beyond specified dates. However, wastes treated in accordance with chemical-specific treatment standards provided in 40 CFR 268 Subpart D may be land-disposed as provided therein. The Land Disposal Restrictions potentially affect the storage and disposal of hazardous wastes generated during RI or subsequent remedial activities and may be considered both action- and chemical-specific ARARs.

6.1.2.4 Treatment, Storage, and Disposal Facilities

If remedial alternatives for the site involve the construction or off-site use of RCRA treatment, storage, or disposal (TSD) facilities, regulations provided in 40 CFR 264 become action-specific ARARs. Various subsections of 40 CFR 264 govern standards and procedures for the operation of hazardous waste TSD facilities. For example, a common disposal practice is to create a waste pile of contaminated soil as part of the remediation process. 40 CFR 264 Subpart L promulgates Federal RCRA standards for waste piles, including their design, operating requirements, monitoring and inspection, closure, and post-closure care. Other subparts control tank systems, surface impoundments, land treatment units, landfills, incinerators, and miscellaneous TSD units.

6.1.3 Safe Drinking Water Act

Federal regulations pursuant to the Safe Drinking Water Act (SDWA) govern the quality, usage, and discharge of groundwater as applied to drinking water quality. MCLs specified in 40 CFR 141.11-16 and 141.60-63 are legally enforceable Federal drinking water standards established by the USEPA. Maximum Contaminant Level Goals (MCLGs) specified in 40 CFR 141.50-52 are non-enforceable, health-based goals for drinking water. MCLGs are set at levels at which no adverse health effects may arise. MCLs are set as close as practical to MCLGs. For non-carcinogens, MCLs are nearly always set at the MCLG. The USEPA believes that MCLs are protective of public health; however, it does recognize that specific circumstances may require more stringent standards (i.e., MCLGs) for the protection of public health and the environment.

6.1.4 Clean Water Act

The Federal Clean Water Act and pursuant regulations provide potential location-, chemical-, and action-specific ARARs for IRP activities at the Seattle ANGS.

6.1.4.1 Ambient Water Quality Criteria

The USEPA has promulgated Ambient Water Quality Criteria (AWQC) for surface water and groundwater through 40 CFR 131. Aligned with the Federal Clean Water Act criteria, the standard governing AWQC presents scientific data and guidance on the environmental effects of pollutants, rather than only establishing regulatory requirements. As a result, decision-makers evaluating remedial alternatives may compare their water quality data to Federal data and guidance. Candidate RAs involving contaminated surface water or groundwater must be evaluated within the context of follow-on water usage and the circumstances of the actual or potential release before implementation. AWQC may be considered when evaluating cleanup levels for groundwater or surface water.

6.1.4.2 National Pollutant Discharge Elimination System

National Pollutant Discharge Elimination System (NPDES) regulations govern discharges to surface water and control surface water runoff from storm water discharge systems. Promulgation of Clean Water Act Section 402 and formal ARARs are established for NPDES through 40 CFR 122 and 40 CFR 125, and provide action- and chemical-specific ARARs.

6.1.5 Occupational Safety and Health Act

RI/FS field activities are governed by Occupational Safety and Health Act (OSHA) standards under 29 CFR 1910. Site workers must meet the requirements of the site health and safety plan, possess and use personal protective equipment in accordance with the health and safety plan, and take all precautions to eliminate exposure to unsafe or unhealthy situations. Other applicable OSHA ARARs include health and safety for Federal service contracts (29 CFR 1926) and record keeping and reporting under 29 CFR 1904.

6.1.6 Hazardous Materials Transportation Act

If material containing hazardous wastes is to be transported off site, U.S. Department of Transportation hazardous material transportation requirements in 49 CFR 171-179, pursuant to the Federal Hazardous Materials Transportation Act, may be action-specific ARARs for RI/FS activities. These requirements are supplemental to RCRA transporter requirements in 40 CFR 263.

6.1.7 Clean Air Act

The Federal Clean Air Act may provide action- and chemical-specific ARARs for IRP activities, including subsequent field investigations and RAs such as soil excavation or incineration. All remediation activities must comply with National Primary and Secondary Ambient Air Quality Standards found in 40 CFR 50. Rules governing particulate matter less than 10 microns in size (PM_{10}) are contained in 40 CFR 50, and are important due to the potential detrimental effects of such particles on the lungs. Field activities involving air emissions must ensure compliance with the PM_{10} standard.

6.1.8 Federal Guidance to be Considered

In addition to Federal and State requirements that may be applicable or relevant and appropriate to IRP activities, Federal non-regulatory criteria must be considered. Chemical-specific Federal non-regulatory criteria, used to help characterize risks and to set cleanup goals, include the following:

- USEPA Risk Reference Doses;
- USEPA Health Advisories;
- USEPA Carcinogen Assessment Group Potency Factors;
- USEPA Acceptable Intake Values, Chronic and Subchronic; and

- USEPA guidance manual on water-related fate of 129 priority pollutants.

6.2 State Requirements

6.2.1 Model Toxics Control Act

The State of Washington has a toxic waste cleanup law called the Model Toxics Control Act (MTCA). MTCA is the State equivalent of CERCLA. MTCA outlines cleanup requirements to ensure the protection of human health and the environment while allowing flexibility in site-specific application of these requirements. The MTCA Cleanup Regulation (WDOE 1996) defines a two-step approach for establishing cleanup requirements for individual sites. The first step is establishing cleanup levels and the second step is selecting cleanup actions that would best achieve the cleanup levels. The following summary of options for selecting cleanup levels is derived from WDOE (1996).

The MTCA Cleanup Regulation provides three options for establishing site-specific cleanup levels. Each of these options uses human health risk as the main determinant in setting cleanup levels.

6.2.1.1 Model Toxics Control Act Method A

MTCA Method A defines cleanup levels for 25 of the most common hazardous substances found at sites (the Method A Tables). These levels were developed using acceptable risk levels outlined in the standards and health-based concentrations that are included in other applicable State and Federal laws. Method A is designed to be used for cleanups that are relatively straightforward or involve only a few hazardous substances, all of which must be listed on the Method A Tables. The Method A approach is used mainly by small sites that do not warrant the costs of conducting risk assessments and extensive site studies.

6.2.1.2 Model Toxics Control Act Method B

MTCA Method B Cleanup Levels are developed using a site risk assessment that focuses on site characteristics, such as how hazardous substances interact with each other, what the combined health effects may be, and how the substances' movement on- and off-site could threaten human heath and the environment. Applicable State and Federal laws must also be followed.

The lifetime excess cancer risk level for individual carcinogens cannot exceed 1×10^{-6}. If more than one type of hazardous substance is present, the total excess cancer risk level at the site may not exceed 1×10^{-5}. Levels for non-carcinogens cannot exceed the point at which a substance may cause illness in humans. For individual hazardous substances, this point is defined by a "hazard quotient" of 1; for multiple substances, the sum of the individual hazard quotients (i.e., the "hazard index") cannot exceed 1. Natural background concentrations and laboratory testing limitations of a substance also can be considered when setting Method B Cleanup Levels.

Method B is the most common method used for setting cleanup levels when sites are contaminated with substances not listed under Method A.

6.2.1.3 Model Toxics Control Act Method C

MTCA Method C is similar to Method B. The main difference is that the lifetime excess cancer risk is set at 1×10^{-5} for both individual carcinogenic substances and for the total risk caused by all substances at a site. This method may be used when cleanup levels under Method A or B are technically impossible to achieve; are lower than area background concentrations; or may potentially result in more harm to human health or the environment than benefits. This method may also be applied to qualifying industrial properties. Use of Method C requires proof to WDOE that the cleanup levels will protect human health and the environment.

6.2.2 Hazardous Waste Management Act

The Washington Hazardous Waste Management Act (70.105 Revised Code of Washington) is the State equivalent of RCRA. The regulations that implement the Hazardous Waste Management Act are known as the Dangerous Waste Regulations, Chapter 173-303 WAC. Regulations governing dangerous-waste management in the State of Washington provide both action- and chemical-specific ARARs that may apply to IRP activities at the Station.

6.2.2.1 Waste Identification

Waste materials generated at the site (e.g., soil cuttings, purge water, decontamination water) are regulated as dangerous waste if they meet the State definition provided in WAC 173-303.

6.2.2.2 Waste Generation and Transport

RI activities or remedial alternatives involving the generation or transport of dangerous waste trigger dangerous-waste generator requirements provided in WAC 173-303. When dangerous waste is shipped off site in regulated amounts, the applicable manifesting and transport procedures must be followed.

SECTION 7.0

CONTAMINANT FATE AND TRANSPORT

This section discusses factors that affect the environmental fate and transport of COPCs at the Seattle ANGS that may pose a threat to human health and/or the environment. Based on a review of COPC concentrations, frequency of detections, inherent toxicity, and presence or potential presence in exposure pathways, none of the COPCs identified at the Station currently pose a significant risk. As discussed in Section 5.0, the presence of TPH in soil in the vicinity of PA/SI boring BS-003BH was not confirmed by the Phase II RI sampling. Additionally, groundwater monitoring conducted at the site since 1996 has yielded only seven VOC detections that exceed MTCA Method A Cleanup Levels (PCE, detected in background wells BS-004PZ and MW-1, and TCE, detected in wells MW-6 and MW-8).

Although VOCs have not been detected consistently above PSGs in groundwater, TCE was detected at concentrations up to 83 μg/l (i.e., 17 times the MTCA Method A Cleanup Level) in three screening-level groundwater samples and three samples collected from monitoring wells in the southern portion of the Station. In addition, TCE has been consistently detected in groundwater monitoring wells at the Boeing site immediately south of the Seattle ANGS, at concentrations up to 1,000 μg/l (Boeing 1998). Consequently, the potential risks associated with the dissolved TCE warrant further evaluation. Potential human health risks associated with the TCE observed in groundwater at the Station are discussed in Section 8.0.

7.1 Physical and Chemical Properties of Contaminants

The primary physical and chemical properties that affect fate and transport of TCE in the environment are its Henry's Law Constant, water solubility, and organic carbon/water partition coefficient. These properties are described below, along with their relevance to contaminant fate and transport; representative numerical values for TCE are summarized on Table 7-1.

TABLE 7-1

Physical and Chemical Factors for Trichloroethene
143rd CCSQ, Seattle ANGS, Seattle, Washington

Henry's Law Constant (atm-m^3/mol)	0.0091
Water Solubility (mg/l)	1,100
Organic Carbon/Water Partition Coefficient (Koc) (ml/g)	126

atm-m^3/mol = Atmospheres-cubic meters per mole
mg/l = Milligrams per liter
ml/g = Milliliters per gram

- The Henry's Law Constant (H) provides a measure of the tendency of a constituent to volatilize or partition from the aqueous or water phase to the vapor phase. Organic compounds having H values greater than 10^{-3} atmospheres-cubic meters per mole (atm-m^3/mol) tend to volatilize from water. Although organic compounds having H values less than 10^{-3} atm-m^3/mol may volatilize from water, other processes such as adsorption to soil are more likely to influence transport. TCE has an H value of 9.1×10^{-3} atm-m^3/mol; consequently, volatilization plays an important role in the fate and transport of TCE.

- Water solubility is an important property affecting compound migration in soil and groundwater. It is expressed in terms of the number of milligrams of a compound that can be dissolved in 1 liter of water under standard conditions of 25 °C and 1 atmosphere pressure. The higher the solubility, the greater the tendency for a compound to dissolve in water and hence be transported through soil and groundwater. The solubility of TCE is 1,100 milligrams per liter (mg/l), which is considered high. For comparison, the solubility of pure benzene, a highly soluble component of petroleum fuels, is 1,780 mg/l.

- The organic carbon/water partition coefficient (Koc) provides a measure of the affinity of a dissolved compound to sorb to organic carbon in soil. Laboratory studies have shown that organic forms of carbon present in soil or aquifer material provide adsorption sites for organic and inorganic contaminants. When a contaminant adsorbs to organic carbon, its movement through soil or groundwater is slowed, or "retarded," because less of the total contaminant mass is available in the dissolved (mobile) fraction. The higher the Koc, the more likely the compound is to adsorb to organic carbon. The Koc for TCE is 126 ml/g. For comparison, Koc values for other common organic contaminants range from 1 ml/g for miscible compounds with very high mobility (e.g., 1,4-dioxane, tetrahydrofuran) to more than 250,000 ml/g for immiscible compounds that are effectively immobile (e.g., benzo[a]pyrene, PCB-1260, chrysene) (Fetter 1988). Within this context, the mobility of dissolved TCE is considered to be moderate to high.

7.2 Potential Routes of Migration

The primary route of migration for the dissolved TCE detected at the Seattle ANGS is transport in groundwater. No hydraulic connection between groundwater at the Seattle ANGS and surface water bodies has been established.

The fate and transport of TCE in groundwater is controlled by its relatively high solubility and volatility, its relatively low tendency to adsorb to organic carbon-containing particulate matter in saturated soils, the rates of biodegradation and biokinetic decay, and the solubility-based diffusive dilution of the compound in the saturated zone.

7.3 Contaminant Persistence

The persistence of VOCs in the subsurface will vary depending on the chemical composition of the compounds and how the compounds interact with the chemical, physical, and biological properties of the soil/groundwater system. Different compounds will dissolve at different rates and in varying amounts in groundwater, sorb more or less strongly to soils, volatilize to varying degrees, and undergo various mechanisms of release and attenuation. Some compounds may also be more susceptible to degradation by chemical or biological action than others. Accordingly, the relative concentration of VOCs will vary with time and distance from the source area.

An important factor controlling the environmental persistence of polychlorinated hydrocarbons such as TCE is the tendency of the original chlorinated compound (parent product) to degrade to lesser molecular weight compounds (daughter products) under appropriate conditions. For example, under reducing conditions, TCE can biodegrade to dichloroethene (DCE), vinyl chloride, and ethene. Processes that can cause degradation and attenuation of TCE in the environment are discussed further below.

7.3.1 Aerobic Processes

Aerobic biodegradation is a biological process in which bacteria utilize oxygen molecules in a water/soil system to degrade organic compounds.

In the aerobic biodegradation process, the bacteria derive energy from the breakdown reaction and utilize the organic compound as a source of carbon. The aerobic process typically involves the addition of oxygen and the removal of hydrogen from the organic compound, such that the compound is oxidized.

The results of early laboratory studies indicated that aerobic degradation of chlorinated hydrocarbons does not occur. More recent studies, however, indicate that aerobic degradation of some chlorinated hydrocarbons (e.g., vinyl chloride) can occur, particularly when the degrading bacteria are stimulated by the addition of methane and oxygen. Nonetheless, aerobic biodegradation of polychlorinated hydrocarbons such as TCE is generally not believed to occur under natural conditions.

7.3.2 Anaerobic Processes

Anaerobic processes are those in which organic compounds are degraded by bacteria in the absence of oxygen. Instead of free oxygen, the anaerobic bacteria utilize inorganic oxygen-bearing compounds such as nitrates, sulfates, and carbon dioxide to degrade organic compounds. Studies have shown that under methanogenic conditions, bacteria can utilize sulfate to facilitate degradation of polychlorinated hydrocarbons such as PCE and TCE via reductive dechlorination.

In the reductive dechlorination process, chlorine atoms are sequentially removed from chlorinated hydrocarbon compounds through anaerobic bacterial action. In this way, a chlorine atom can be removed from TCE resulting in transformation to one or more DCE isomers. Continued reductive dechlorination transforms DCE to vinyl chloride. The dechlorination process ends with the transformation of vinyl chloride to ethene. DCE and vinyl chloride are referred to as intermediary chemical components in the reductive dechlorination process. Anaerobic biodegradation of chlorinated hydrocarbons was discovered when aquifers were found contaminated with intermediary chemical components that had not historically been used at the overlying sites.

Studies have shown that during anaerobic biodegradation, the relative ratios of intermediary chemical components such as DCE and vinyl chloride are dependent upon the level of methanogenic activity in the water/soil system. Under typical environmental conditions, DCE will be more prevalent than vinyl chloride. When methanogenic activity is very high, however, vinyl chloride will be the predominant intermediary chemical component. Laboratory studies have also shown that 1,1-DCE, trans-1,2-DCE, and cis-1,2-DCE are formed in varying amounts during anaerobic biodegradation of TCE. It has been suggested that pH plays a role in the specific DCE isomers formed from the reductive dechlorination of TCE.

In summary, while it is known that chlorinated hydrocarbons will biodegrade through anaerobic processes, the specific conditions required to initiate and maintain those processes are not well understood. The presence of only low concentrations of a chlorinated compound in a water/soil system may not be adequate to stimulate the bacterial growth needed to initiate the anaerobic process. In addition, certain oxygen sources may be required by the degrading bacteria in order to break down specific compounds. For example, there is conflicting research regarding the degradability of TCE under denitrifying conditions. Finally, the conditions that affect the rate and extent to which anaerobic biodegradation can occur in the environment are not completely quantified. It has been suggested that favorable conditions for chlorinated hydrocarbon degradation include a dissolved oxygen content of less than 0.5 mg/l in groundwater and a redox potential of less than -100 millivolts (USEPA 1998).

7.3.3 Abiotic Processes

Abiotic processes include strictly chemical and photochemical reactions, and physical processes such as leaching and volatilization. Abiotic processes can play an important role in the degradation and attenuation of organic compounds in the subsurface. Volatilization is probably the most important abiotic process affecting persistence of TCE in the environment, due to the compound's relatively high volatility. In addition, abiotic reductive dechlorination of TCE to form DCE has been shown to be possible. However, reductive dechlorination is typically a biological process, and it is not considered to occur abiotically to any significant extent in the environment.

7.4 Contaminant Migration

Transport mechanisms for TCE in groundwater include advection (transport via groundwater flow) and diffusion. The presence of TCE in groundwater is controlled by its solubility, which in turn determines the amount of dissolved TCE available for transport. The solubility of TCE is relatively high (1,100 mg/l) and its affinity for soils is relatively low. Consequently, dissolved TCE is considered to be moderately to highly mobile in groundwater. In general, the rate of TCE transport via advection depends on the rate of groundwater flow at a site, whereas transport via diffusion is controlled primarily by the TCE concentration gradients in groundwater. Diffusion is also dependent on hydraulic gradients; as hydraulic gradient magnitudes decrease, the relative importance of diffusional transport increases.

SECTION 8.0

BASELINE RISK ASSESSMENT

The State of Washington has developed human health risk assessment procedures for use in establishing site-specific cleanup levels for sites impacted by hazardous substances (WAC 173-340-708). These procedures were used to evaluate the potential human health risks associated with the TCE detected in groundwater at the Seattle ANGS. TCE was detected at concentrations up to 83 μg/l in six groundwater samples collected in the southern portion of the Station. Additionally, TCE concentrations up to 1,000 μg/l have been consistently detected in groundwater monitoring wells at the Boeing site immediately south of the Station.

This section describes the purpose, methods, and results of the baseline risk assessment conducted for TCE in groundwater at the Seattle ANGS. Since groundwater monitoring at the Station has not detected consistent TCE concentrations above the MTCA Method A Cleanup Level, the baseline risk assessment is presented for information only, and is not intended to be used for decision-making purposes.

8.1 Purpose of the Baseline Risk Assessment

A baseline risk assessment provides an evaluation of the potential threat to human health posed by contaminants of concern at a site in the absence of any remedial action. If ecological receptors exist, the baseline risk assessment may include an evaluation of potential ecological risks. The baseline risk assessment provides the basis for determining whether or not remedial action is necessary and the justification for performing the remedial action.

The objective of the screening-level baseline risk assessment conducted for the Seattle ANGS was to provide an estimate of the potential health risks associated with exposure to the observed concentrations of TCE in groundwater. The risk assessment was performed using data generated during the RI. As no ecological receptors were identified during the RI, only human health risks were quantified.

8.2 Contaminants of Potential Concern

TCE in groundwater is the only COPC at the Seattle ANGS considered to pose a potential threat to human health. TCE was detected at concentrations up to 83 µg/l in six groundwater samples collected during the RI, including three screening-level (direct-push) samples and three samples collected from groundwater monitoring wells.

8.3 Human Health Risk Assessment

An assessment of the potential human health risks associated with the observed TCE concentrations in groundwater at the Station was performed according to the exposure and risk characterization procedures and specifications used to derive site-specific MTCA Method B Cleanup Levels (WAC 173-340-720[3]). The health risk assessment consisted of a toxicity assessment, an exposure assessment, and characterization of risks. These components are described separately below.

8.3.1 Toxicity Assessment

The toxicity assessment consists of collecting available data regarding the potential for COPCs to cause adverse effects in exposed individuals. These toxicity data are used in conjunction with exposure assumptions derived from the exposure assessment to characterize the associated potential human health risks. The toxicity assessment for the Seattle ANGS relied on existing data published in scientific literature and did not involve the development of new data on toxicity or dose-response relationships. The WDOE publishes an annual update of toxicological data for use in calculating cleanup levels under MTCA. The most recently available update from WDOE and the USEPA Integrated Risk Information System (IRIS) database were used in performing the toxicity assessment for the Seattle ANGS.

Published toxicity factors used in the assessment of human health risks include:

- **USEPA Reference Doses (RfDs).** Oral and inhalation RfDs are USEPA toxicity values for evaluating non-carcinogenic health effects associated with individual compounds. RfDs are used in conjunction with exposure assumptions derived from the exposure assessment to characterize potential non-carcinogenic health risks. RfDs are expressed in units of mg/kg-day.

- **Carcinogenic Potency Factors (CPFs).** Oral and inhalation CPFs are USEPA values that characterize the carcinogenic potency of a compound. CPFs are used in conjunction with exposure assumptions to quantify potential carcinogenic health risks. CPFs are expressed in units of kg-day/mg or $(mg/kg/day)^{-1}$, denoting a numerical risk per milligram of compound per kilogram of body weight per day of exposure.

Since TCE is a carcinogen, the potential cancer risks associated with exposure to TCE were evaluated in the baseline risk assessment. The CPF for oral exposure to TCE (i.e., drinking water ingestion) is 0.011 kg-day/mg.

8.3.2 Exposure Assessment

This section presents the method used to assess potential human exposures to the TCE in groundwater at the Seattle ANGS. The method that was used is based on the MTCA approach for developing site-specific Method B Cleanup Levels for groundwater (WAC 173-340-720[3]). The MTCA approach considers drinking water to be the highest potential beneficial use of groundwater expected to occur under both current and future site-use conditions. The reasonable maximum exposure to hazardous substances is assumed to occur through ingestion of drinking water and inhalation of volatile substances during showering and other domestic water uses. The MTCA approach is thus conservative from the standpoint of estimating exposures for the evaluation of human health risks.

The estimated carcinogenic exposure dose for TCE was calculated as follows:

$$\text{Exposure Dose} = \frac{\text{Concentration (mg/l)} \times \text{INH} \times \text{Ingestion rate (l/day)} \times \text{Exposure duration}}{\text{Avg. body wt. (kg)} \times \text{Lifetime duration}}$$

Exposure dose is expressed in units of mg/kg-day. INH is the inhalation correction factor, which is equal to 2 for volatile organic hazardous substances such as TCE (WAC 173-340-720[7]). In accordance with MTCA requirements (WAC 173-340-720[3][a][ii][B]), the drinking water ingestion rate was assumed to be 2 liters per day, the average body weight was assumed to be 70 kg, the exposure duration was assumed to be 30 years, and the lifetime duration was assumed to be 75 years. The TCE concentration used in calculating exposure dose was the maximum concentration detected during the RI (0.083 mg/l, in monitoring well MW-8 in February 1999).

Using the above equation and assumptions, the calculated carcinogenic exposure dose for TCE is 1.90×10^{-3} mg/kg-day. This calculated exposure dose was used in conjunction with the CPF described in Section 8.3.1 to estimate the numeric cancer risk associated with ingesting groundwater containing TCE at the maximum concentration observed in groundwater monitoring wells at the Station.

8.3.3 Risk Characterization

Cancer risk is expressed as the incremental probability of a person contracting cancer over a lifetime as a result of exposure to a known or suspected carcinogen. "Incremental" refers to the fact that the cancer risk is in excess of the person's normal risk without this exposure. The estimated excess cancer risk is calculated by multiplying the exposure dose by the CPF:

$$\text{Excess Cancer Risk} = \text{Exposure Dose} \times \text{CPF}$$

The USEPA has an excess cancer risk goal range of 1×10^{-6} to 1×10^{-4} (USEPA 1989), where an excess cancer risk of 1×10^{-6} is equivalent to one excess incidence of cancer in 1,000,000 people and an excess risk of 1×10^{-4} indicates a risk of one in 10,000. The WDOE upper bound on the acceptable excess cancer risk for individual hazardous substances is 1×10^{-6} (WAC 173-340-705[2][c][ii]).

Using the above equation, the estimated excess cancer risk associated with the maximum TCE concentration detected in groundwater monitoring wells at the Seattle ANGS is 2.09×10^{-5}. This value exceeds the WDOE acceptable cancer risk level of 1×10^{-6}.

8.4 Uncertainty Analysis

The results of the quantitative human health risk assessment presented in Section 8.3.3 contain various degrees of uncertainty that reflect uncertainties in the underlying assumptions of the risk assessment. These uncertainties include:

- Uncertainty in the laboratory analytical results;

- Uncertainty in the toxicological bases of published toxicity factors (reference dose and carcinogenic potency factor);
- Uncertainty in the exposure assumptions and exposure factor values used in the risk calculations; and
- The cumulative uncertainty in calculated risks resulting from the mathematical manipulation of the above factors.

With the exception of laboratory analytical results, the factors listed above are conservative in nature and typically lead to overestimates of risk. Laboratory analytical results contain uncertainties inherent in various stages of the analytical process. For example, USEPA analytical QA/QC guidelines allow a ±20 percent error in the calibration for metals. If the sample matrix produces interferences (a common occurrence in environmental samples), a 25 percent or greater underestimate or overestimate of the true analyte concentration could occur. The net result of these analytical uncertainties is that analyte concentrations reported by laboratories may contain positive or negative biases of this magnitude.

Unlike the uncertainty in analytical results, the uncertainty associated with toxicological data is usually conservative in nature because the RfDs and CPFs are developed by the USEPA with the intent that even sensitive members of the population will be sufficiently protected. For example, an examination of the USEPA's IRIS database shows that the safety factors used in computing RfDs range from 10 to 10,000.

The CPFs used in risk assessment represent the 95 percent UCL value derived from available published data. This means that actual risks are unlikely to be higher than the potential risks estimated in the baseline risk assessment, but they may be considerably lower. Use of the 95 percent UCL CPF value is consistent with the USEPA and WDOE approach of using reasonable maximum exposure scenarios in estimating risk. Reasonable maximum exposure is defined as the highest exposure that can reasonably be expected to occur at a site. Risk evaluations based on reasonable maximum exposure scenarios are intended to be conservative by characterizing the risks to a maximally exposed receptor. This approach is thus inherently conservative and tends to overestimate risk.

The estimation of cancer risks in the baseline risk assessment followed USEPA and WDOE guidelines. These guidelines rely on the use of "default exposure factors" for estimating risks associated with reasonable maximum exposures. As with toxicological data, default exposure factors are used to ensure that potential receptors are adequately protected. The default exposure factors are conservative by design, and thus, contribute to the conservative nature of the baseline risk assessment.

SECTION 9.0

CONCLUSIONS

Soil, soil vapor, and groundwater samples were collected at the Seattle ANGS to characterize potential environmental contamination related to historical operations at the Station. COPCs detected above Washington State MTCA Method A Cleanup Levels include benzene, PCE, and TCE in groundwater:

- Benzene was detected at a concentration of 7.6 µg/l in one screening-level groundwater sample collected in the southern portion of the Station.

- PCE was detected at concentrations of 5.1 to 17 µg/l in four groundwater samples collected from background monitoring wells along the northern Station boundary.

- TCE was detected at concentrations of 5.7 to 83 µg/l in six groundwater samples collected in the southern portion of the Station (three screening-level samples and three samples from monitoring wells). Prior to the detection of 83 µg/l in February 1999, TCE had not been detected above the MTCA Method A Cleanup Level in any on-site monitoring wells.

Despite extensive sampling of soil and groundwater during the RI, an on-site source of the VOCs detected in groundwater has not been identified. TCE has been consistently detected in shallow groundwater monitoring wells at the Boeing site immediately south of the Station, at concentrations up to 1,000 µg/l (Boeing 1998). Although the Boeing site is hydraulically downgradient of the Seattle ANGS, dissolved contaminants at the Boeing site may have migrated beneath the Seattle ANGS via diffusion (i.e., concentration-driven dispersion) or some other mechanism. This could at least partially explain the distribution of relatively low VOC concentrations observed in groundwater in the southern portion of the Station.

A screening-level baseline risk assessment was performed to estimate the potential human health risks associated with exposure to the observed concentrations of TCE in groundwater at the Station. The health risks were evaluated using the highest TCE concentration detected during the RI groundwater monitoring program (83 μg/l). The reasonable maximum exposure scenario used in the baseline risk assessment was the use of site groundwater for drinking water and other domestic purposes. The estimated excess cancer risk associated with ingestion and inhalation exposures to TCE under this scenario is 2.09×10^{-5}. This value exceeds the WDOE acceptable cancer risk level of 1×10^{-6}.

SECTION 10.0

RECOMMENDATIONS

Continued quarterly groundwater monitoring for 1 year is recommended to assess trends in VOC concentrations and to evaluate compliance with MTCA. Site-specific remedial action objectives and potential remedial alternatives for groundwater are discussed in the Phase II Feasibility Study Report (ERM 1999).

SECTION 11.0

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APPENDIX A

TECHNICAL MEMORANDA FOR FIELD ACTIVITIES

Technical Memorandum

To: Rob Leet, Don Wyll, Scott Miyamoto

From: Mike Arnold

Subject: Phase II Remedial Investigation Field Memorandum
July - September 1998 Field Work
Seattle ANGS, Seattle, Washington

Date: 27 July 1998

This document outlines the details of soil vapor, soil, and groundwater sampling to be completed during the Phase II Remedial Investigation (RI) at the Seattle Air National Guard Station (ANGS) located in Seattle, Washington in July through September 1998. Soil vapor samples will be collected from 40 vapor probes, soil and groundwater samples will be collected from 20 geoprobe locations, 5 monitoring wells will be installed and developed, and 13 groundwater samples will be collected from the new and existing wells at the site. The locations of the proposed soil vapor probes, Geoprobe sites, and proposed and existing monitoring wells are shown on Figures 6-1 and 6-2 in the Work Plan.

Phase II RI field activities will be performed in the northwest and southern portions of the Seattle ANGS. Table 6-1 on page 6-2 in the Work Plan outlines the number and type of samples to be collected, and the number of soil vapor probes, Geoprobe sites, and monitoring wells to be completed at the Seattle ANGS during the Phase II RI.

Health and Safety Requirements

All site personnel are to be familiar with and must follow the Sitewide Safety and Health Plan, which is included in the Work Plan as Appendix A. This includes using the correct levels of personal protective equipment (PPE). The Site Safety Officer (Site Manager) will ensure that all personnel present during fieldwork fill out the daily tailgate forms.

Soil Vapor Sampling

Soil vapor samples will be collected from 40 locations at the Seattle ANGS as shown on Figure 6-1 of the Work Plan. Soil vapor sampling information recorded during this investigation will be included in a bound field notebook. Once equipment decontamination procedures have been completed, soil vapor samples will be collected by pushing a stainless steel probe into the soil using a Geoprobe-type sampling system to a target depth of 5 feet below ground surface (bgs). A screen at the tip of the probe will be exposed by retracting the probe rod a few inches. A vacuum pump will be used to purge at least five volumes of air from the probe rods. The soil vapor samples will be collected in evacuated volatile organics analysis (VOA) vials, stainless steel canisters, or Tedlar™ sample bags. Soil vapor samples will be analyzed in an on-site mobile laboratory for volatile organic compounds (VOCs) by USEPA Method 8010/8020.

Geoprobe Soil Sample Collection

Soil samples will be collected from 20 Geoprobe sites (GP-23 through GP-42) at the Seattle ANGS during the Phase II RI. The sampling locations are shown on Figure 6-2 of the Work Plan. Borehole logging/sampling forms to be used during this investigation will be included in a bound field notebook. Soil borings will be completed using the direct push drilling method. Once equipment decontamination procedures have been completed, undisturbed soil samples will be collected by pushing a stainless steel split-spoon drive sampler lined with stainless steel sleeves into the soil using a Geoprobe-type sampling system to a target depth of 6 to 9 feet bgs (i.e., just above the water table).

The lower-most or least disturbed split-spoon sleeve collected from directly above the water table in each borehole will be immediately sealed upon collection using a Teflon barrier, aluminum foil (shiny side up), and plastic end caps. This sample will be labeled and designated for analysis at an off-site laboratory. An additional sample sleeve may be similarly prepared for quality assurance/quality control (QA/QC) sample requirements. One or more of the remaining split-spoon sleeves from each drive sample interval will be field-screened using a photoionization detector (PID).

The soil samples will be analyzed for VOCs by USEPA Method 8260. Additionally, the soil samples collected from directly above the water table in borings GP-23, GP-24, and GP-25 will also be analyzed for hydrocarbon identification by Washington Department of Ecology (WDOE) Method WTPH-HCID.

A portion of each drive sample, if enough sample is recovered, will be field-screened for organic vapors using a PID. The field screening will consist of placing a portion of the sample in a sealable plastic bag or glass sample jar covered with aluminum foil, gently agitating the bag or jar for approximately 30 seconds, and allowing the sample temperature to equilibrate to ambient conditions (out of sunlight) for approximately 15 minutes. After this time, the PID probe will be pushed through the side of the bag or through the aluminum foil into the bag or jar headspace, and the concentration of organic vapors in the headspace will be recorded on the drilling log.

The following figure shows the sampling scheme for the drive sampler. From each drive sample, the lower-most sleeve will be for laboratory analysis, and if applicable, the second sleeve will be submitted for field duplicate or laboratory matrix spike/matrix spike duplicate (MS/MSD) analysis. The second (or third) sleeve from the bottom will be used for field screening with a PID. The remaining sleeves will be used for lithology evaluation.

Drive Sampler Sampling Scheme

Duplicate or MS/MSD Sample Collected	No Duplicate or MS/MSD Sample Collected
Lithology	Lithology
PID & Lithology	Lithology
Field Duplicate or MS/MSD	PID & Lithology
Laboratory	Laboratory

Samples designated for laboratory analysis will be labeled, placed in individual sealed plastic bags, and stored on ice. Sample label information will be written directly on the sample sleeve with a permanent marker.

HydroPunch Groundwater Sample Collection

Groundwater samples will be collected from each of the 20 Geoprobe sites at the Seattle ANGS using the HydroPunch or equivalent method. One groundwater sample will be collected from each site from a depth of approximately 2.5 feet below the water table. The groundwater samples will be collected using a peristaltic pump and disposable polyethylene tubing. The groundwater samples will be analyzed for VOCs by USEPA Method 8010/8020 in an on-site mobile field laboratory.

Monitoring Well Installation

Five groundwater monitoring wells (MW-6 through MW-10) will be installed at the Seattle ANGS in August 1998 using hollow-stem auger methods in compliance with Washington State regulations and WDOE guidance. The proposed monitoring well locations are shown on Figure 6-2 of the Work Plan. Monitoring wells will be completed to a target depth of 20 feet bgs with screened interval between 5 feet and 20 feet bgs. Note that at least 1 foot of filter pack sand must be present beneath the well point at each well location. Monitoring well construction details are summarized in Section 7.0 of the Work Plan; the proposed monitoring well construction is shown on Figure 7-1. Well casing materials will be decontaminated prior to installation, unless they are removed from sealed plastic wrapping immediately prior to installation. A performance test will be conducted after the well is completed to ensure the well is straight and has not collapsed.

Soil samples will be collected at 5-foot intervals during drilling, for lithologic logging and field-screening using a PID. The lower-most sample sleeve containing unsaturated soil from the sample collected at 5 feet bgs will be analyzed for VOCs by USEPA Method 8260 at the off-site laboratory.

Monitoring Well Development

Within 24 to 48 hours after completion, the monitoring wells will be developed by the drilling subcontractor or ERM using a properly decontaminated submersible pump or a bailer. The water level in the well will be measured before development begins. Temperature, conductivity, turbidity, and pH will be monitored and recorded while a minimum of 10 well casing volumes plus three times the amount of any potable water added are purged from the well. Well development will continue until temperature, pH, turbidity, and conductivity have stabilized.

Monitoring Well Groundwater Sampling

In September 1998, groundwater samples will be collected from the 8 existing and 5 new monitoring wells at the Seattle ANGS. The locations of the monitoring wells are shown on Figure 6-2 of the Work Plan. The water level in each well will be measured prior to beginning sampling activities. Monitoring wells will be purged and sampled using a nondedicated submersible pump. Low-flow purging procedures (pumping rate of less than 1 liter per minute) will be used at all wells. Prior to sample collection, monitoring well purging will continue until at least three well casing volumes have been evacuated or the groundwater temperature, pH, specific conductivity, and turbidity have stabilized to within ±10 percent, unless the monitoring well purges dry and does not recover readily. If the monitoring well purges dry, the well will be purged completely once and allowed to recover over a period of not more than 18 hours prior to sampling. Groundwater samples will be collected directly from the pump discharge tubing and analyzed for VOCs by USEPA Method 8260 as listed on Table 6-2 of the Work Plan.

Sampling Schedule

The current schedule for field sampling activities during the July through September 1998 mobilizations of the Seattle ANGS Phase II RI is as follows:

23-27 July 1998:	ERM personnel meet with site personnel, mark sampling locations, and complete utility clearance on site;
28-30 July 1998:	Complete soil vapor survey;
11-13 August 1998:	Complete Geoprobe/HydroPunch sampling;
27-28 August 1998:	Complete monitoring well installation and development;
1-3 September 1998:	Sample monitoring wells, meet surveyor on site to develop Phase II RI soil boring location data.

This schedule may be altered due to Station operations and/or sampling rate.

Soil Vapor Sample Identifiers

Sample identifiers for primary soil vapor samples will be the same as the soil vapor probe number. For example, "SVS-17" represents the soil vapor sample collected from vapor probe SVS-17.

Soil Sample Identifiers

Sample identifiers for primary soil samples will include the soil boring or monitoring well number and sample depth; the sample depth will be designated as the deepest depth penetrated by the split-spoon sampler. For example, "GP-24-7"represents the sample collected at 7 feet bgs in Geoprobe boring GP-24.

Groundwater Sample Identifiers

Sample identifiers for primary Geoprobe/HydroPunch groundwater samples will be the same as the Geoprobe boring number. For example, the groundwater sample collected from Geoprobe boring GP-31 will be designated "GP-31."

Sample identifiers for primary groundwater samples collected from monitoring wells will include the monitoring well identifier, the calendar year, and the sequential sampling event within that year. For example, "MW1-98-1" represents a groundwater sample collected from monitoring well MW-1 during the first sampling event of 1998. The September 1998 quarterly sampling event will be the first groundwater sampling event in 1998.

Analytical Parameters

Soil vapor, soil, and groundwater samples collected during the Seattle ANGS Phase II RI field activities will be analyzed for the parameters listed on Table 6-2 of the Work Plan.

Soil vapor and Geoprobe/HydroPunch groundwater samples collected during the Phase II RI will be analyzed in an on-site mobile field laboratory operated by Transglobal Environmental Geosciences Northwest, Inc.

All soil and monitoring-well groundwater sample analyses will be performed by MultiChem Analytical Services (MAS). Samples will be hand delivered to MAS at the following address:

MAS
ATTN: Sample Receiving
560 Naches Avenue Southwest, Suite 101
Renton, Washington 98055-2200
Phone: (425) 228-8335
Fax: (425) 363-1742

A Level IV CLP-type data package will be requested from MAS for selected soil samples collected during one day or for a group of samples listed on one Chain-of-Custody form. The particular set of samples designated for Level IV documentation will be selected in the field. The sample group selected for Level IV documentation must contain an MS/MSD-designated sample for each matrix and requested analysis. Level IV documentation is required for approximately 10 percent of the soil analyses (i.e., approximately two 8260 analyses and one WTPH-HCID analysis). All monitoring-well groundwater sample analyses (100 percent) will require Level IV documentation.

Quality Assurance/Quality Control (QA/QC) Samples

The following QA/QC samples will be collected during RI activities at the site: trip blanks, field duplicates, equipment rinsate blanks, field blanks, and MS/MSD samples. One trip blank will be submitted with each cooler containing samples for VOC analysis at the off-site laboratory; the trip blanks will be analyzed for VOCs using USEPA Method 8260. Field blanks, equipment rinsate blanks, and duplicates will be analyzed for the same parameters as the primary samples.

Duplicate Samples. Field duplicates will be collected at a frequency of 10 percent of the total number of primary samples. Sample identifiers for field duplicates are the same as the primary sample but followed by a "D." The collection times recorded for the field duplicates should be the same as the associated primary samples.

Duplicate soil vapor samples will be collected from the following soil vapor probes:

- **SVS-5, SVS-15, SVS-25, SVS-35**

Duplicate soil samples will be collected from the following Geoprobe borings:

- **GP-24, GP-36**

Duplicate groundwater samples will be collected from the following locations:

- HydroPunch: **GP-26, GP-36**

- Monitoring Well: **MW-3**

Equipment Rinsate Blanks. Equipment rinsate blanks will be analyzed at a frequency of 10 percent of the number of primary samples. The equipment rinsate blanks will be collected from the final ASTM Type II water rinse of the sampling equipment after decontamination. Sample identifiers for rinsate blanks will be the same as the sample identifier used for the sample collected before the blank was prepared, followed by an "R."

Equipment rinsate blanks for soil vapor samples will be collected at the following locations:

- **SVS-5, SVS-15, SVS-25, SVS-35**

Equipment rinsate blanks for soil samples will be collected at the following locations:

- **GP-24, GP-36**
- **MW-6**

Equipment rinsate blanks for groundwater samples will be collected at the following locations:

- HydroPunch: **GP-26, GP-36**
- Monitoring Well: **MW-3**

Field Blanks. Field blanks will be collected at the frequency of one per water source (i.e., tap water, ASTM Type II water) per sampling event. Sample identifiers for field blanks will be the identifier used for the sampling location at which the blank was prepared, followed by an "FT" (for tap water) or "FA" (for ASTM Type II water).

Field blanks for soil vapor samples will be collected at the following location:

- **SVS-15**

Field blanks for Geoprobe/HydroPunch soil and groundwater samples will be collected at the following location:

- **GP-24**

Field blanks for monitoring-well groundwater samples will be collected at the following location:

- Monitoring Well: **BS-004PZ**

MS/MSD. One MS/MSD will be designated for every 20 soil and every 20 groundwater samples. No standardized method for developing soil vapor sample MS/MSDs is available. MS/MSDs will be designated to be performed on a soil sample from the following Geoprobe soil boring:

- **GP-24**

MS/MSDs will be designated to be performed on the following groundwater samples:

- HydroPunch: **GP-35**

- Monitoring Well: **BS-004PZ**

Extra sample volumes need to be collected for MS/MSD analyses for each type of analysis performed. VOC analysis typically requires triple sample volume, while other analyses require double volume. Confirm required MS/MSD sample volumes with the laboratory prior to sample collection. MS/MSD-designated samples should be indicated on the Chain-of-Custody form. At least one MS/MSD sample is required for each matrix in each sample batch designated for Level IV CLP-type laboratory data reporting.

Trip Blanks. Trip blanks will be collected at the frequency of one per cooler containing samples designated for VOC analysis at the off-site laboratory. Sample identifiers for trip blanks are as follows: TB(date)-#. For example "TB081198-1" and "TB081198-2" represent the trip blanks submitted with the first and second coolers, respectively, containing samples collected on 11 August 1998.

Decontamination

All sampling equipment will be decontaminated prior to sampling, between samples, and after sampling activities have been completed. Decontamination will include scrubbing sampling equipment with a laboratory-grade detergent (e.g., Liqui-Nox or Alconox) and potable water mixture, followed by a rinse with ASTM Type II reagent water, and a final methanol spray rinse. All equipment will be allowed to air dry, if possible, and either wrapped in aluminum foil or positioned to preclude inadvertent contamination prior to reuse.

The drilling rigs, augers, and downhole rods will be decontaminated after use by steam cleaning.

Used decontamination water will be contained in 55-gallon drums.

Site Survey

In preparation for the site survey, each Geoprobe/HydroPunch boring location completed in paved areas will be clearly marked and labeled with paint. Boring locations in unpaved areas will be clearly marked with labeled wooden stakes and flagging. Boring locations in unpaved areas will also be measured from nearby features as necessary to aid in locating the borehole for surveying should the stake be removed.

Landmark, Inc. (425-340-1100) will complete a survey of the Geoprobe/HydroPunch boring locations and new monitoring wells at the Seattle ANGS on a date to be arranged. Horizontal and vertical coordinates for the Phase II RI boring and monitoring well locations will be surveyed. Landmark should be contacted as soon as possible following any change in schedule that may affect the scheduled surveying date.

Work Plan Sampling Summary

The Phase II RI sampling program is summarized in Section 6.0 of the Work Plan. Note that soil sampling during monitoring well installation was added to the scope of work after the Final Work Plan was submitted; therefore, this element of the sampling program is not discussed in Section 6.0.

Deviations /Clarifications from the Work Plan

The collection of soil samples at 5-foot intervals during monitoring well installation and the submittal of one soil sample from each monitoring well boring (and one equipment rinsate sample) for VOC analysis are not included in the scope of work outlined in the Work Plan. No other deviations from the Work Plan are anticipated during this field effort.

Daily Reporting

A summary of each day's field activities, including copies of borehole logs, Chain-of-Custody forms, etc., will be prepared by the ERM Site Manager and will be delivered to the ERM Project Manager by 8 am the following day.

Required Equipment and Materials

Equipment and materials to be transported to the site by the Site Manager or their designates:

- Copy of Work Plan
- Copy of Site Health & Safety Plan
- Stainless steel soil sample sleeves 2" diameter x 6" (drillers will supply)
- Teflon film, perforated 4" square sheets
- Plastic end caps for soil sample sleeves (drillers will supply)
- Photoionization detector (PID) with calibration gas
- Coolers
- Methanol
- ASTM Type II reagent water system
- Alconox or Liqui-Nox
- Aluminum foil
- Borehole logging/sampling record notebook
- Calibration forms
- Chain-of-Custody forms
- Sample labels
- Drum labels
- Sitewide Safety and Health Plan with fit letters and training certificates
- Submersible pump, hose, and controllers
- Back-up submersible pump and disposable tubing
- Peristaltic pump and disposable tubing
- Horiba, Minisonde, or equivalent water quality meter with in-line flow cell and calibration standards
- Camera and film
- 5 Waterproof, bound field notebooks
- Water level indicator
- pH paper
- Decontamination buckets and brushes
- Spray bottles & tank
- Roll of plastic sheeting
- Nitrile gloves (10 boxes)
- Tool kit
- Sample bottles
- Paper towels
- Ziploc bags
- Ice
- Stainless steel scoop/trowel
- Disposable bailers (10)
- Measuring wheel or tape (50'-100')
- Weather proof pens
- 1 box Tyvek coveralls
- First aid kit
- Eye wash kit
- Fire extinguisher

Technical Memorandum

To: Rob Leet, Scott Miyamoto

From: Don Wyll

Subject: Phase II Remedial Investigation Field Memorandum
November 1998 Groundwater Sampling
Seattle ANGS, Seattle, Washington

Date: 5 November 1998

This document outlines the details of quarterly groundwater sampling to be completed during the Phase II Remedial Investigation (RI) at the Seattle Air National Guard Station (ANGS) located in Seattle, Washington in November 1998. Groundwater samples will be collected from the 13 existing wells at the site. The locations of the monitoring wells are shown on the attached figure.

Health and Safety Requirements

All site personnel are to be familiar with and must follow the Sitewide Safety and Health Plan, which is included in the Work Plan as Appendix A. This includes using the correct levels of personal protective equipment (PPE). The Site Safety Officer (Site Manager) will conduct a daily safety tailgate briefing and ensure that all personnel present during fieldwork sign the daily tailgate forms.

Groundwater Sampling

In November 1998, groundwater samples will be collected from the 13 monitoring wells at the Seattle ANGS. The water level in each well will be measured prior to beginning sampling activities. Monitoring wells will be purged and sampled using a nondedicated submersible pump. Low-flow purging procedures (pumping rate of less than 1 liter per minute) will be used at all wells. Prior to sample collection, monitoring well purging will continue until at least three well casing volumes have been evacuated or the groundwater temperature has stabilized to within $\pm$ 1°C, pH has stabilized to within 0.1 units, and specific conductance has stabilized to within ±10 percent. If the monitoring well purges dry, the well will be purged completely once and allowed to recover over a period of not more than 18 hours prior to sampling. Groundwater samples will be collected directly from the pump discharge tubing and analyzed for volatile organic compounds (VOCs) by U.S. Environmental Protection Agency (USEPA) Method 8260.

Sampling Schedule

The current schedule for field sampling activities during the November 1998 mobilization of the Seattle ANGS Phase II RI is as follows:

23-25 November 1998: Mobilize to site, measure water levels, complete groundwater sampling.

This schedule may be altered due to Station operations and/or sampling rate.

Groundwater Sample Identifiers

Sample identifiers for groundwater samples collected from monitoring wells will include the monitoring well identifier, the calendar year, and the sequential sampling event within that year. For example, "MW-1-98-2" represents a groundwater sample collected from monitoring well MW-1 during the second sampling event of 1998. The November 1998 quarterly sampling event will be the second groundwater sampling event in 1998.

Analytical Parameters

All groundwater sample analyses will be performed by MultiChem Analytical Services (MAS). Samples will be hand delivered to MAS at the following address:

MAS
ATTN: Sample Receiving
560 Naches Avenue Southwest, Suite 101
Renton, Washington 98055-2200
Phone: (425) 228-8335
Fax: (425) 363-1742

A Level IV CLP-type data package will be requested from MAS for all groundwater sample analyses (100 percent Level IV reporting).

Quality Assurance/Quality Control (QA/QC) Samples

The following QA/QC samples will be collected during RI activities at the site: trip blanks, field duplicates, equipment rinsate blanks, field blanks, and matrix spike/matrix spike duplicate (MS/MSD) samples. The QA/QC samples will be analyzed for VOCs by USEPA Method 8260.

Duplicate Samples. Field duplicates will be collected at a frequency of 10 percent of the total number of primary samples. Sample identifiers for field duplicates are the same as the primary sample but followed by a "D." The collection times recorded for the field duplicates should be the same as the associated primary samples.

One duplicate groundwater sample will be collected at the following location:

- Monitoring Well: **MW-3**

Equipment Rinsate Blanks. Equipment rinsate blanks will be analyzed at a frequency of 10 percent of the total number of primary samples. The equipment rinsate blanks will be collected from the final American Society for Testing and Materials (ASTM) Type II water rinse of the sampling equipment after decontamination. Sample identifiers for rinsate blanks will be the same as the sample identifier used for the sample collected before the blank was prepared, followed by an "R."

One equipment rinsate blank sample will be collected at the following location:

- Monitoring Well: **MW-3**

Field Blanks. Field blanks will be collected at the frequency of one per water source (i.e., tap water, ASTM Type II water) per sampling event. Sample identifiers for field blanks will be the identifier used for the sampling location at which the blank was prepared, followed by an "FT" (for tap water) or "FA" (for ASTM Type II water).

One tap water field blank and one ASTM Type II water field blank will be collected at the following location:

- Monitoring Well: **BS-004PZ**

MS/MSD. The MS/MSD analyses will be designated to be performed on the groundwater sample collected at the following location:

- Monitoring Well: **BS-004PZ**

24-25 February 1999: Mobilize to site, measure groundwater levels, complete groundwater sampling.

This schedule may be altered due to Station operations and/or sampling rate.

Groundwater Sample Identifiers

Sample identifiers for groundwater samples collected from the monitoring wells will include the monitoring well identifier, the calendar year, and the sequential sampling event within that year. For example, "MW1-99-1" represents a groundwater sample collected from monitoring well MW-1 during the first sampling event of 1999. The February 1999 quarterly sampling event will be the first groundwater sampling event in 1999.

Analytical Parameters

All soil and monitoring-well groundwater sample analyses will be performed by MultiChem Analytical Services (MAS). Samples will be hand delivered to MAS at the following address:

MAS
ATTN: Sample Receiving
560 Naches Avenue Southwest, Suite 101
Renton, Washington 98055-2200
Phone: (425) 228-8335
Fax: (425) 363-1742

The samples will be analyzed for VOCs by USEPA Method 8260 All monitoring-well groundwater sample analyses (100 percent) will require Level IV CLP-type data package documentation.

Quality Assurance/Quality Control (QA/QC) Samples

The following QA/QC samples will be collected during RI activities at the site: trip blanks, field duplicates, equipment rinsate blanks, field blanks, and MS/MSD samples. One trip blank will be submitted with each cooler containing samples for VOC analysis at the off-site laboratory; the trip blanks will be analyzed for VOCs using USEPA Method 8260. Field blanks, equipment rinsate blanks, and duplicates will be analyzed for the same parameters as the primary samples.

Duplicate Samples. Two field duplicates will be collected in February 1999. Sample identifiers for field duplicates are the same as the primary sample but followed by a "D." The collection times recorded for the field duplicates should be the same as the associated primary samples.

Duplicate groundwater samples will be collected at the following locations:

- Monitoring Well: **MW-4, MW-8**

Equipment Rinsate Blanks. One equipment rinsate blank will be collected in February 1999. The equipment rinsate blanks will be collected from the final ASTM Type II water rinse of the sampling equipment after decontamination. The sample identifier for the rinsate blank will be the same as the sample identifier used for the sample collected before the blank was prepared, followed by an "R."

The equipment rinsate blank sample will be collected at the following location:

- Monitoring Well: **MW-4**

Field Blanks. One tap water field blank and one ASTM Type II water field blank will be collected in February 1999. Sample identifiers for field blanks will be the identifier used for the sampling location at which the blank was prepared, followed by an "FT" (for tap water) or "FA" (for ASTM Type II water).

The two field blanks will be collected at the following location:

- Monitoring Well: **MW-4 (or MW-8)**

MS/MSD. One MS/MSD will be designated to be performed on the groundwater sample collected from the following location:

- Monitoring Well: **MW-4 (or MW-8)**

Extra sample volumes need to be collected for MS/MSD analyses for each type of analysis performed. VOC analysis typically requires triple sample volume, while other analyses require double volume. **Confirm required MS/MSD sample volumes with the laboratory prior to sample collection**. MS/MSD-designated samples should be indicated on the Chain-of-Custody form. At least one MS/MSD sample is required for each matrix in each sample batch designated for Level IV CLP-type laboratory data reporting.

Trip Blanks. Trip blanks will be collected at the frequency of one per cooler containing samples designated for VOC analysis at the off-site laboratory. Sample identifiers for trip blanks are as follows: TB(date)-#. For example "TB022499-1" and "TB022499-2" represent the trip blanks submitted with the first and second coolers, respectively, containing samples collected on 24 February 1999.

Decontamination

Non-disposable monitoring and sampling equipment will be decontaminated before and after use at each monitoring well. The electronic water level indicator and the submersible pump housing will be washed with a mixture of tap water and laboratory-grade detergent (e.g., Liqui-Nox or Alconox), followed by a rinse with ASTM Type II reagent-grade water, and a final isopropanol spray rinse. The submersible pump internals and any non-disposable tubing will be decontaminated by pumping an aqueous Alconox or Liqui-Nox solution, followed by ASTM Type II water, through the pump and tubing. The ASTM Type II water will be produced on site from tap water using a portable water filtration system. Decontaminated equipment will be either wrapped in aluminum foil or positioned to preclude inadvertent contamination prior to reuse. Decontamination water will be contained in 55-gallon drums.

Work Plan Sampling Summary

The groundwater sampling program is summarized in Section 6.0 of the Phase II RI/FS Work Plan.

Deviations /Clarifications from the Work Plan

The QA/QC sample naming convention (i.e., sample identifiers) specified in this memorandum differs from the convention described in the Work Plan. Also, isopropanol will be used for the final decontamination spray rinse instead of methanol. Both of these deviations have been approved by the ANG Project Manager (Alan Klavans). No other deviations from the Work Plan are anticipated during the February 1999 sampling event.

Daily Reporting

A summary of each day's field activities, including copies of chain-of-custody forms and field notes, will be prepared by the ERM Site Manager and will be delivered to the ERM Project Manager upon completion of each sampling event.

Required Equipment and Materials

Equipment and materials to be transported to the site by the field sampling team include:

- First aid kit
- Eye wash kit
- Fire extinguisher
- PPE (hard hats, safety glasses, traffic vests, etc.)
- Copy of Final Phase II RI/FS Work Plan (July 1998)
- Copy of Sitewide Safety and Health Plan (Appendix A of Work Plan)
- Bound field book containing appropriate monitoring, sampling, and health & safety forms and documentation (including fit letters and training certificates)
- Calibration forms
- Chain-of-custody forms
- Weatherproof, bound field notebooks
- Weatherproof pens
- Photoionization detector (PID) with isobutylene calibration gas
- Submersible pump and controller
- Submersible pump hose and/or disposable tubing
- Back-up submersible pump and controller
- Disposable bailers
- Water quality meter with in-line flow cell
- Electronic water level indicator
- Sample bottles and labels
- Drum labels
- Coolers
- Resealable plastic bags

- ASTM Type II reagent-grade water system
- Decontamination buckets and scrub brushes
- Alconox or Liqui-Nox
- Isopropanol
- Spray bottles and/or tank
- Plastic sheeting
- Nitrile gloves
- Aluminum foil
- Paper towels
- Tool kit
- Camera and film
- Ice

Technical Memorandum

Environmental
Resources
Management

915 - 118th Avenue S.E.
Suite 130
Bellevue, WA 98005
(425) 462-8591
(425) 455-3573 (fax)

To: Rob Leet, Amy Kelley

From: Don Wyll

Date: 14 May 1999

Subject: Quarterly Groundwater Monitoring –
Fourth Quarter 1998/99 Groundwater Sampling Event
Seattle ANGS, Seattle, WA

ERM®

This document outlines the details of groundwater water sample collection to be completed in May 1999 at the Seattle Air National Guard Station (ANGS) located in Seattle, Washington. Groundwater samples will be collected from 13 monitoring wells at the site. The locations of the monitoring wells are shown on the attached figure.

Health and Safety Requirements

All site personnel are to be familiar with and must follow the Sitewide Safety and Health Plan, which is included in the Work Plan as Appendix A. This includes using the correct levels of personal protective equipment (PPE). The Site Safety Officer (Site Manager) will conduct a daily safety tailgate briefing and ensure that all personnel present during fieldwork sign the daily tailgate forms.

Groundwater Sample Collection

Groundwater samples will be collected from the 13 existing monitoring wells at the Seattle ANGS. The depth to groundwater in each monitoring well will be measured with an electronic water level indicator before any of the wells are purged or sampled. Monitoring wells will then be purged and sampled using a non-dedicated submersible pump. Low-flow sampling methods will be used as described in the following Standard Operating Procedure (SOP):

SOP for Low-Flow Sampling

1. Attach a fresh piece of disposable polyethylene (or equivalent) tubing to outlet of decontaminated pump. Lower pump slowly into well to minimize mixing of casing water and suspension of any silt at bottom of well. Place pump near the middle or slightly above the middle of the screened interval. (Note: these initial steps are only necessary if using a non-dedicated pump or if installing a dedicated pump.) Purge at 100 to 500 ml/min; the goal is to minimize drawdown in the well (ideally less than 10 cm drawdown).

2. Monitor purge-water temperature, pH, specific conductance, dissolved oxygen, oxidation-reduction (redox) potential, and turbidity using an in-line flow cell. (Also take discrete turbidity measurements using a bench-top turbidity meter if this is specified in the approved Work Plan.) Take readings every 3 to 5 minutes.

3. Stop purging when the following parameters have stabilized as defined below for three successive readings or when at least one well casing volume has been purged:

   Temperature: ± 1 C;

   pH: ± 0.1 units;

   Specific conductance: ± 10 percent;

   Dissolved oxygen or turbidity: ± 10 percent; and

   For metals/inorganics sampling with no field filtering:
   turbidity < 30 NTU.

4. When only unfiltered samples will be collected for metals/inorganics analysis, if parameters do not stabilize within one casing volume or turbidity does not fall below 30 NTU, let the water level in the well recover overnight, but less than 24 hours, before collecting the metals/inorganics samples. However, samples to be analyzed for organics should be sampled immediately following purging. Metals/inorganics samples should be collected the next day according to the procedure outlined below under "Quiescent Sampling of Low-Yield Wells."

5. After well-purging criteria are satisfied, disconnect the in-line flow cell and collect samples as usual (VOCs first, followed by TPH, SVOCs, and metals/inorganics samples as applicable).

6. If required by the Work Plan, take a photograph of the purge water in a clear glass container against a white background. The sampling location should be clearly identified in the photograph.

7. If using a non-dedicated pump, remove pump from well, discard disposable tubing, and decontaminate pump per the Work Plan/ANG protocol.

To minimize delays in field parameter stabilization and potential bias in analytical testing results, any vents or other potential sources of air bubbles in the pump discharge tubing or in-line flow cell should be identified and sealed off (or otherwise isolated) prior to purging or as soon as possible after purging begins.

Quiescent Sampling of Low-Yield Wells

If well yield is so low that continuous flow is lost during well purging even at the minimum sustainable purge rate, turn the pump off and allow the well to recover as much as possible (but not longer than 24 hours). If only unfiltered samples will be collected for metals/inorganics, allow the well to recover overnight. Do not attempt to maximize purge volume by lowering the pump to the bottom of the well. After the water level in the well has recovered, collect the required samples with the pump placed near the middle of the screened interval. If using a non-dedicated pump, be sure to minimize disturbance of the water column by lowering the pump slowly into the well.

Groundwater samples at the Seattle ANGS will be collected directly from the pump discharge tubing and analyzed for volatile organic compounds (VOCs) using USEPA Method 8260.

Sampling Schedule

The current schedule for field sampling activities during the May 1999 groundwater sampling event at the Seattle ANGS is as follows:

18-19 May 1999: Mobilize to site, measure groundwater levels, complete groundwater sampling.

This schedule may be altered due to Station operations and/or sampling rate.

Groundwater Sample Identifiers

Sample identifiers for groundwater samples collected from the monitoring wells will include the monitoring well identifier, the calendar year, and the sequential sampling event within that year. For example, "MW1-99-2" represents a groundwater sample collected from monitoring well MW-1 during the second sampling event of 1999. The May 1999 quarterly sampling event will be the second groundwater sampling event in 1999.

Analytical Parameters

All soil and monitoring-well groundwater sample analyses will be performed by MultiChem Analytical Services (MAS). Samples will be hand delivered to MAS at the following address:

MAS
ATTN: Sample Receiving
560 Naches Avenue Southwest, Suite 101
Renton, Washington 98055-2200
Phone: (425) 228-8335
Fax: (425) 363-1742

The samples will be analyzed for VOCs by USEPA Method 8260 All monitoring-well groundwater sample analyses (100 percent) will require Level IV CLP-type data package documentation.

Quality Assurance/Quality Control (QA/QC) Samples

The following QA/QC samples will be collected during RI activities at the site: trip blanks, field duplicates, equipment rinsate blanks, field blanks, and MS/MSD samples. One trip blank will be submitted with each cooler containing samples for VOC analysis at the off-site laboratory; the trip blanks will be analyzed for VOCs using USEPA Method 8260. Field blanks, equipment rinsate blanks, and duplicates will be analyzed for the same parameters as the primary samples.

Duplicate Samples. One field duplicate will be collected in May 1999. The sample identifier for field duplicate will be the same as the primary sample but followed by a "D." The collection times recorded for the field duplicates should be the same as the associated primary sample.

The duplicate groundwater sample will be collected at the following location:

- Monitoring Well: **MW-8**

Equipment Rinsate Blanks. One equipment rinsate blank will be collected in May 1999. The equipment rinsate blank will be collected from the final ASTM Type II water rinse of the sampling equipment after decontamination. The sample identifier for the rinsate blank will be the same as the sample identifier used for the sample collected before the blank was prepared, followed by an "R."

The equipment rinsate blank sample will be collected at the following location:

- Monitoring Well: **MW-4**

Field Blanks. One tap water field blank and one ASTM Type II water field blank will be collected in May 1999. Sample identifiers for field blanks will be the identifier used for the sampling location at which the blank was prepared, followed by an "FT" (for tap water) or "FA" (for ASTM Type II water).

The two field blanks will be collected at the following location:

- Monitoring Well: **MW-4 (or MW-8)**

MS/MSD. One MS/MSD will be designated to be performed on the groundwater sample collected from the following location:

- Monitoring Well: **MW-4 (or MW-8)**

Extra sample volumes need to be collected for MS/MSD analyses for each type of analysis performed. VOC analysis typically requires triple sample volume, while other analyses require double volume. **Confirm required MS/MSD sample volumes with the laboratory prior to sample collection.** MS/MSD-designated samples should be indicated on the Chain-of-Custody form. At least one MS/MSD sample is required for each matrix in each sample batch designated for Level IV CLP-type laboratory data reporting.

Trip Blanks. Trip blanks will be collected at the frequency of one per cooler containing samples designated for VOC analysis at the off-site laboratory. Sample identifiers for trip blanks are as follows: TB(date)-#. For example "TB022499-1" and "TB022499-2" represent the trip blanks submitted with the first and second coolers, respectively, containing samples collected on 24 May 1999.

Decontamination

Non-disposable monitoring and sampling equipment will be decontaminated before and after use at each monitoring well. The electronic water level indicator and the submersible pump housing will be washed with a mixture of tap water and laboratory-grade detergent (e.g., Liqui-Nox or Alconox), followed by a rinse with ASTM Type II reagent-grade water, and a final isopropanol spray rinse. The submersible pump internals and any non-disposable tubing will be decontaminated by pumping an aqueous Alconox or Liqui-Nox solution, followed by ASTM Type II water, through the pump and tubing. The ASTM Type II water will be produced on site from tap water using a portable water filtration system. Decontaminated equipment will be either wrapped in aluminum foil or positioned to preclude inadvertent contamination prior to reuse. Decontamination water will be contained in 55-gallon drums.

Work Plan Sampling Summary

The groundwater sampling program is summarized in Section 6.0 of the Phase II RI/FS Work Plan.

Deviations/Clarifications from the Work Plan

The QA/QC sample naming convention (i.e., sample identifiers) specified in this memorandum differs from the convention described in the Work Plan. Also, isopropanol will be used for the final decontamination spray rinse instead of methanol. Both of these deviations have been approved by the ANG Project Manager (Alan Klavans). No other deviations from the Work Plan are anticipated during the May 1999 sampling event.

Daily Reporting

A summary of each day's field activities, including copies of chain-of-custody forms and field notes, will be prepared by the ERM Site Manager and will be delivered to the ERM Project Manager upon completion of each sampling event.

Required Equipment and Materials

Equipment and materials to be transported to the site by the field sampling team include:

- First aid kit
- Eye wash kit
- Fire extinguisher
- PPE (hard hats, safety glasses, traffic vests, etc.)
- Copy of Final Phase II RI/FS Work Plan (July 1998)
- Copy of Sitewide Safety and Health Plan (Appendix A of Work Plan)
- Bound field book containing appropriate monitoring, sampling, and health & safety forms and documentation (including fit letters and training certificates)
- Calibration forms
- Chain-of-custody forms
- Weatherproof, bound field notebooks
- Weatherproof pens
- Photoionization detector (PID) with isobutylene calibration gas
- Submersible pump and controller
- Submersible pump hose and/or disposable tubing
- Back-up submersible pump and controller
- Disposable bailers
- Water quality meter with in-line flow cell
- Electronic water level indicator
- Sample bottles and labels
- Drum labels
- Coolers
- Resealable plastic bags

- ASTM Type II reagent-grade water system
- Decontamination buckets and scrub brushes
- Alconox or Liqui-Nox
- Isopropanol
- Spray bottles and/or tank
- Plastic sheeting
- Nitrile gloves
- Aluminum foil
- Paper towels
- Tool kit
- Camera and film
- Ice

Technical Memorandum

To: Rob Leet, Scott Miyamoto

From: Don Wyll

Subject: Phase II Remedial Investigation Field Memorandum
November 1998 Groundwater Sampling
Seattle ANGS, Seattle, Washington

Date: 5 November 1998

This document outlines the details of quarterly groundwater sampling to be completed during the Phase II Remedial Investigation (RI) at the Seattle Air National Guard Station (ANGS) located in Seattle, Washington in November 1998. Groundwater samples will be collected from the 13 existing wells at the site. The locations of the monitoring wells are shown on the attached figure.

Health and Safety Requirements

All site personnel are to be familiar with and must follow the Sitewide Safety and Health Plan, which is included in the Work Plan as Appendix A. This includes using the correct levels of personal protective equipment (PPE). The Site Safety Officer (Site Manager) will conduct a daily safety tailgate briefing and ensure that all personnel present during fieldwork sign the daily tailgate forms.

Groundwater Sampling

In November 1998, groundwater samples will be collected from the 13 monitoring wells at the Seattle ANGS. The water level in each well will be measured prior to beginning sampling activities. Monitoring wells will be purged and sampled using a nondedicated submersible pump. Low-flow purging procedures (pumping rate of less than 1 liter per minute) will be used at all wells. Prior to sample collection, monitoring well purging will continue until at least three well casing volumes have been evacuated or the groundwater temperature has stabilized to within $\pm$ 1°C, pH has stabilized to within 0.1 units, and specific conductance has stabilized to within ±10 percent. If the monitoring well purges dry, the well will be purged completely once and allowed to recover over a period of not more than 18 hours prior to sampling. Groundwater samples will be collected directly from the pump discharge tubing and analyzed for volatile organic compounds (VOCs) by U.S. Environmental Protection Agency (USEPA) Method 8260.

Sampling Schedule

The current schedule for field sampling activities during the November 1998 mobilization of the Seattle ANGS Phase II RI is as follows:

23-25 November 1998: Mobilize to site, measure water levels, complete groundwater sampling.

This schedule may be altered due to Station operations and/or sampling rate.

Groundwater Sample Identifiers

Sample identifiers for groundwater samples collected from monitoring wells will include the monitoring well identifier, the calendar year, and the sequential sampling event within that year. For example, "MW-1-98-2" represents a groundwater sample collected from monitoring well MW-1 during the second sampling event of 1998. The November 1998 quarterly sampling event will be the second groundwater sampling event in 1998.

Analytical Parameters

All groundwater sample analyses will be performed by MultiChem Analytical Services (MAS). Samples will be hand delivered to MAS at the following address:

MAS
ATTN: Sample Receiving
560 Naches Avenue Southwest, Suite 101
Renton, Washington 98055-2200
Phone: (425) 228-8335
Fax: (425) 363-1742

A Level IV CLP-type data package will be requested from MAS for all groundwater sample analyses (100 percent Level IV reporting).

APPENDIX B

BOREHOLE LOGS AND WELL CONSTRUCTION DIAGRAMS

ERM
915 118th Avenue S.E.
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: GP-23

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/13/98

Ground Surface Elevation: 15.09'
X Coordinate: 5530.26
Y Coordinate: 5568.69
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 8.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete 0.2–2.75' Brown SILT with fine SAND, moist, stiff.
		SM					2.75–5.75' Grades to silty, fine SAND, moist, dense.
5		SP					5.75'– Grades to medium to fine SAND, with trace silt, moist.
			▼				Becomes wet at 8.0 feet.
10							Boring completed at 11.0 feet bgs.
15							
20							

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SEA407939

ERM
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BOREHOLE LOG

Site Id: GP-24

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: Cascade Drilling
Drilling Method: Direct Push
Logged By: D. Wyll

X Coordinate:
Y Coordinate:
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 8.50'
Date(s): 08/13/98

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
							0.0–0.2' Asphaltic Concrete
		ML					0.2–3.5' Black-gray SILT with fine SAND, moist, stiff.
						0.0	Becomes brown.
		SP					3.5'– Gray, fine SAND with trace silt.
5						0.5	Grades to fine-medium SAND, moist, dense.
							Silty sand lense.
			▼			0.0	Groundwater encountered at ~8.0 feet. Becomes wet at ~8.5 feet.
10							Boring Completed at 11.0 feet.
15							
20							

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ERM
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BOREHOLE LOG

Site Id: GP-25
Page 1 of 1

Project Number: 6051.31	Ground Surface Elevation: 15.07'
Project Name: Seattle Air National Guard	X Coordinate: 5512.71
Location: Seattle, WA	Y Coordinate: 5560.88
Contractor: TEG	Total Depth: 11.00'
Drilling Method: Direct Push	Borehole Dia.: 2.00in
Logged By: D. Wyll	Static Water Level: 8.50'
Date(s): 08/13/98	

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2–3.0' Brown–gray SILT with fine SAND, moist, stiff.
		SP					3.0'– Gray–brown, fine SAND with trace silt, moist, dense.
5						0.8	Grades to fine–medium SAND, moist, dense.
			▼				Becomes wet at 8.25 feet.
10							Boring completed at 11.0 feet.
15							
20							

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ERM
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BOREHOLE LOG

Site Id: GP-26

Project Number: 6051.31	Ground Surface Elevation: 14.46'
Project Name: Seattle Air National Guard	X Coordinate: 5670.18
Location: Seattle, WA	Y Coordinate: 5340.33
Contractor: TEG	Total Depth: 11.00'
Drilling Method: Direct Push	Borehole Dia.: 2.00in
Logged By: D. Wyll	Static Water Level: 8.00'
Date(s): 08/13/98	

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2–3.5' Brown-gray SILT with fine SAND, moist, stiff.
						0.0	
		SP					3.5'– Gray, fine SAND with trace silt, moist, dense.
5						10	
							Brown, fine to medium SAND.
			▼	⊠		21	Becomes wet at 8.0 feet. Ground water encountered at 8.0 feet.
						1.0	
10							
							Boring completed at 11.0 feet.
15							
20							

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BOREHOLE LOG

Site Id: GP-27
Page 1 of 1

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/13/98

Ground Surface Elevation: 15.05'
X Coordinate: 5704.31
Y Coordinate: 5434.26
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 8.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2–3.5' Brown-gray SILT with fine SAND, occasional gravel, moist, stiff.
						0.0	
		SP				0.0	3.5'– Gray, fine SAND with trace silt, moist, dense.
5							
							Becomes fine to medium SAND.
						1.3	
			▼				Becomes wet at 8.0 feet.
10							
							Boring Completed at 11.0 feet.
15							
20							

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BOREHOLE LOG

Site Id: GP-28

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/13/98

Ground Surface Elevation: 14.91'
X Coordinate: 5656.02
Y Coordinate: 5412.69
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 7.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
							0.0–0.2' Asphaltic Concrete
		SM					0.2–3.5' Brown-black SILT with fine SAND, trace gravel, moist, medium stiff.
						0.0	
		SP					3.5'– Gray, fine SAND with trace silt, moist, dense.
5						0.0	
							Gray, fine to medium SAND with trace silt, moist to wet.
			▼			0.0	Becomes wet at 7.0 feet.
						0.0	
10							Boring completed at 11.0 feet BGS.
15							
20							

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BOREHOLE LOG

Site Id: GP-29

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/13/98

Ground Surface Elevation: 14.88'
X Coordinate: 5586.65
Y Coordinate: 5263.70
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 9.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2'–4.4' Black-gray SILT with fine SAND, moist, stiff.
						1.0	
5		SM				0.0	4.4'–6.5' Brown-gray, silty, fine SAND, moist, dense.
		SP					6.5'– Gray, fine SAND with trace silt, moist, dense.
			▼			1.0	Becomes wet at 9.0 feet.
10							Boring Completed at 11.0 feet BGS.
15							
20							

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BOREHOLE LOG

Site Id: GP-30
Page 1 of 1

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/13/98

Ground Surface Elevation: 14.68'
X Coordinate: 5529.51
Y Coordinate: 5354.25
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 8.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2–3.5' Brown-gray SILT with fine SAND, moist, stiff.
						0.6	
		SP					3.5'– Gray brown, fine SAND with trace silt, moist, dense.
5							
						0.0	
						0.5	Becomes wet at 8.5 feet.
10							
							Boring completed at 11.0 feet.
15							
20							

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BOREHOLE LOG

Site Id: GP-31
Page 1 of 1

Project Number: 6051.31	Ground Surface Elevation: 14.30'
Project Name: Seattle Air National Guard	X Coordinate: 5505.61
Location: Seattle, WA	Y Coordinate: 5313.67
Contractor: TEG	Total Depth: 11.00'
Drilling Method: Direct Push	Borehole Dia.: 2.00in
Logged By: D. Wyll	Static Water Level: 8.50'
Date(s): 08/13/98	

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		SM					0.0–0.2' Asphaltic Concrete
						0.0	0.2–2.25' Brown-gray, silty, fine SAND, moist, dense.
		ML				0.0	2.25–3.5' Grades to brown SILT with fine SAND, moist, stiff.
		SP					3.5–8.8' Fine SAND with trace silt, moist, dense.
5						0.5	
		SM	▼			1.0	Becomes wet at 8.5 feet.
							8.8'– Brown-gray, silty, fine SAND, wet, dense.
10							
							Boring Completed at 11.0 feet.
15							
20							

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BOREHOLE LOG

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/13/98

Ground Surface Elevation: 14.24'
X Coordinate: 5494.33
Y Coordinate: 5423.85
Total Depth: 11.00'
Borehole Dia.: 2.00in
Static Water Level: 7.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2'–3.0' Black-brown SILT with fine SAND, moist, stiff.
						0.6	
		SP					3.0'– Gray, fine SAND with trace silt, moist, dense.
5						0.0	
							Grades to medium SAND.
			▼			1.7	Becomes wet at 7.5 feet.
10							
							Boring completed at 11.0 feet.
15							
20							

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(425) 462-8591

BOREHOLE LOG

Site Id: GP-33

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 13.34'
X Coordinate: 5224.56
Y Coordinate: 5117.88
Total Depth: 9.00'
Borehole Dia.: 2.00in
Static Water Level: 8.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0-0.2' Asphaltic concrete.
						0.0	0.2-3.0' gray brown SILT with fine sand, moist, stiff.
		SP/SM				0.0	3.0-4.0' gray, fine SAND, with silt, grades to fine sand with trace silt, moist, dense.
5		SP					4.0-9.0' gray, fine to medium SAND, with trace silt, moist, dense.
						0.0	
			▼				Becomes wet at 8.0 feet.
							Boring completed at 9.0 feet BGS.
10							
15							
20							

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BOREHOLE LOG

Site Id: GP-34

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.43'
X Coordinate: 5090.97
Y Coordinate: 5246.39
Total Depth: 10.00'
Borehole Dia.: 2.00in
Static Water Level: 6.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML				1.2	0.0-0.2' Asphaltic concrete. 0.2-5.5' black SILT, with fine sand, moist, stiff.
						0.0	gray brown SILT, with trace sand, moist, dense.
5		SM	▼				5.5'-7.0' gray brown, silty fine SAND, wet, dense.
		SP/SM				0.0	7.0-10.0' very fine SAND WITH SILT, wet, dense.
10							Boring completed at 10 feet BGS.
15							
20							

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SEA407950

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Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: GP-35

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.78'
X Coordinate: 5122.91
Y Coordinate: 5234.97
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 7.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2–2.25' Black-gray SILT with fine SAND, moist.
						0.0	
		SP/SM					2.25–7.0' Black, fine SAND with SILT, moist, dense.
						0.0	Gray brown, fine to medium SAND with SILT, moist, dense.
5							
			▼			0.0	
		ML					7.0'– Brown gray SILT with fine SAND, wet, dense.
							Boring Completed at 9.5 feet.
10							
15							
20							

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SEA407951

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Suite 130
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(425) 462-8591

BOREHOLE LOG

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEC
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.56'
X Coordinate: 5115.69
Y Coordinate: 5168.89
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 7.00'

Depth (ft)	USCS Code	Water Level	Blow Count	PID (ppm)	Description/Soil Classification
	ML				0.0–0.2' Asphaltic Concrete
					0.2–3.0' Black/gray SILT with no sand.
				2.9	Brown gray SILT with fine SAND, moist, stiff.
	SP/SM				3.0–5.75' Gray brown, fine SAND with SILT, moist, dense.
				0.0	
5					
	ML			0.0	5.75'– Gray SILT with trace fine sand, wet, stiff.
		▼			
				0.0	
					Boring completed at 9.5 feet BGS.
10					
15					
20					

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SEA407952

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(425) 462-8591

BOREHOLE LOG

Site Id: GP-37

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.77'
X Coordinate: 5124.39
Y Coordinate: 5100.41
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 7.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		SP/SM					0.0–0.2' Asphaltic Concrete
							0.2–3.0' Gray-brown, fine SAND with SILT, trace gravel, moist, dense.
						0.0	Lenses of silt.
		SP				0.0	3.0–7.8' Brown grey fine to medium SAND with trace silt, moist, dense.
5							Silt lenses.
							SAND becomes finer.
							Ground water encountered at ~6.5 feet.
		ML				0.0	7.8'– Brown SILT with fine SAND, wet, stiff.
10							Boring completed at 9.5 feet BGS.
15							
20							

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SEA407953

ERM
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Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: GP-38

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.46'
X Coordinate: 5067.35
Y Coordinate: 5135.94
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 6.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		SM					0.0–0.2' Asphaltic Concrete
							0.2–2.5' Brown-gray, silty fine SAND, moist, dense.
						1.0	
		ML				0.0	2.5–4.0' Brown-gray, SILT with fine SAND, moist, stiff.
		SP/SM					4.0'– Brown, fine SAND with SILT, wet, dense.
5			▼			0.0	Ground water encountered at ~6.5 feet.
						0.0	
							Boring completed at 9.5 feet.
10							Boring abandoned with Bentonite chips (hydrated).
15							
20							

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SEA407954

ERM
915 118th Avenue S.E.
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 11.98'
X Coordinate: 5046.86
Y Coordinate: 5231.15
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 7.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		SM					0.0–0.2' Asphaltic Concrete
						2.0	0.2–6.5' Brown-gray, fine SAND with SILT, moist, dense.
						0.0	
							Brown-gray, fine to medium SAND with SILT, moist to wet, medium dense.
5						7.0	
							Gray, fine SAND with SILT, occasional gravel, wet, dense.
		ML	▼				6.5'– Gray SILT with fine SAND, wet, stiff.
						1.0	
10							Boring completed at 9.0 feet.
							Ground water sample obtained.
15							
20							

KCSlip4 41425

SEA407955

ERM
915 118th Avenue S.E
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: GP-40

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 11.43'
X Coordinate: 4993.69
Y Coordinate: 5239.48
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 6.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic Concrete
							0.2–3.5' Gray-brown, fine to medium SAND with SILT, moist, dense.
						0.5	Interbedded silt lenses.
							Gray-brown SILT with fine SAND, moist.
		SP/SM				0.5	3.5–6.25' Brown-gray, fine SAND with SILT, moist, wet.
5						0.0	
							Ground water encountered at ~6.5 feet.
		SP	▼				6.25'– Fine to medium SAND, with occasional gravel and trace silt, wet, dense.
						0.0	
							Boring completed at 9.5 feet BGS.
10							
15							
20							

KCSlip4 41426

SEA407956

ERM
915 118th Avenue S.E
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: GP-41
Page 1 of 1

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.12'
X Coordinate: 4986.82
Y Coordinate: 5128.67
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 6.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		SM					0.0–0.2' Asphaltic concrete.
						0.0	0.2–2.0' brown gray, silty fine SAND, moist, dense.
		SP/SM					2.0–5.5' gray, fine SAND WITH SILT, moist, dense.
						1.0	
5							
		ML	▼			0.0	5.5–6.2' brown gray SILT, with fine sand, moist to wet, dense.
		SM					6.2–9.5' gray brown silty , fine SAND, wet, dense.
						0.0	
10							Boring complete at 9.5 feet BGS.
							Ground water sample obtained.
							Boring abandoned with hydrated bentonite chips.
15							
20							

KCSlip4 41427

SEA407957

ERM
915 118th Avenue S.E.
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: GP-42

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: TEG
Drilling Method: Direct Push
Logged By: D. Wyll
Date(s): 08/12/98

Ground Surface Elevation: 12.97'
X Coordinate: 5048.89
Y Coordinate: 5058.05
Total Depth: 9.50'
Borehole Dia.: 2.00in
Static Water Level: 6.00'

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Count	PID (ppm)	Description/Soil Classification
		ML					0.0–0.2' Asphaltic concrete.
							0.2–2.0' gray brown SILT, with fine sand, moist, stiff.
		SP/SM				0.0	2.0–5.5' gray brown, fine to medium SAND, with silt, moist, dense.
						1.0	
5						0.0	
		SM	▼				5.5–7.0' gray brown, silty fine SAND, wet, dense.
							7.0–9.5' gray brown, medium SAND, with trace silt, wet, dense.
						0.0	
10							Boring completed at 9.5 feet BGS. Boring abandoned with hydrated bentonite chips.
15							
20							

KCSlip4 41428

SEA407958

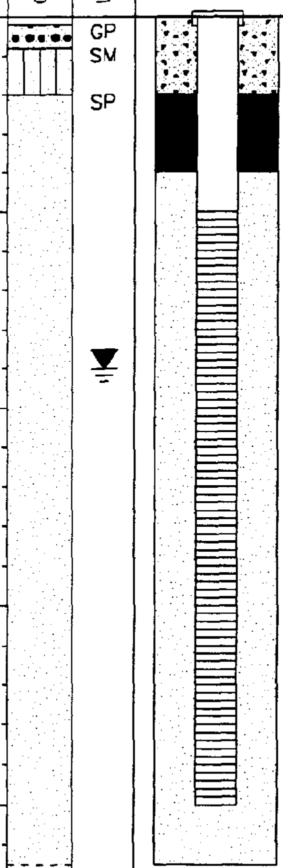
ERM
915 118th Avenue S.E.
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 08/27/98
Total Depth: 21.50'
Completed Depth: 20.00'
Borehole Dia.: 4.25in

Ground Surface Elevation: 11.98'
Top of Casing Elevation: 11.62'
X Coordinate: 5039.52
Y Coordinate: 5166.02
Static Water Level: 9.00'

Blank Casing: type: Sch 40 PVC		dia: 2.00in	fm: 0.0'	to: 5.00'
Screens: type: Slotted	size: 0.010in	dia: 2.00in	fm: 5.00'	to: 20.00'
Annular Fill: type: Concrete			fm: 0.00'	to: 2.00'
type: Bentonite			fm: 2.00'	to: 4.00'
type: 10-20 Silica Sand			fm: 4.00'	to: 21.50'



Depth (ft)	USCS Code	Sample Recovery / Blow Counts	PID (ppm)	Description/Soil Classification
0.0	GP			0.0-0.2' Asphaltic Concrete.
				0.2-0.8' Gray, angular, fine GRAVEL, little sand, clay, loose (base coarse fill).
	SM			0.8-2.0' Brown, silty, fine SAND, trace to little gravel, loose, moist (fill).
2.0	SP			2.0'- Brown, fine SAND, trace to little silt, loose, moist (fill).
5		13, 14, 12		None to little silt, trace gravel below 5.0 feet. No field screening sample-not enough recovery.
				None to trace silt, no gravel below 7.5 feet. Color gray below 8.0 feet. Wet below 9.0 feet.
10		21, 27, 25	0.0	
15		11, 16, 13	0.0	
20		12, 19, 15	0.0	Bottom of boring at 21.5 feet.

KCSlip4 41429

SEA407959

ERM
915 118th Avenue S.E.
Suite 150
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: MW-9

Page 1 of 1

Project Number: 6051.31

Project Name: Seattle Air National Guard

Location: Seattle, WA

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Logged By: M. Arnold

Date(s): 08/27/98

Total Depth: 21.50'

Completed Depth: 20.00'

Borehole Dia.: 4.25in

Ground Surface Elevation: 14.65'

Top of Casing Elevation: 14.30'

X Coordinate: 5628.73

Y Coordinate: 5418.64

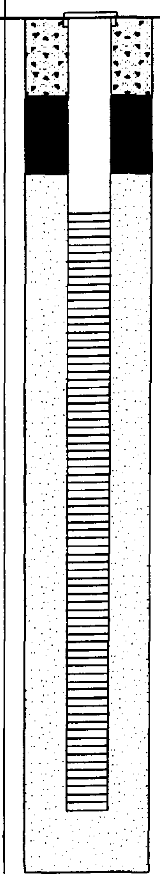
Static Water Level: 9.00'

Blank Casing:				
type: Sch 40 PVC		dia: 2.00in	fm: 0.0'	to: 5.00'

Screens:				
type: Slotted	size: 0.010in	dia: 2.00in	fm: 5.00'	to: 20.00'

Annular Fill:		
type: Concrete	fm: 0.00'	to: 2.00'
type: Bentonite	fm: 2.00'	to: 4.00'
type: 10-20 Silica Sand	fm: 4.00'	to: 21.50'

Depth (ft)	USCS Code	Blow Counts	PID (ppm)	Description/Soil Classification
0	GP			0.0-0.2' Asphaltic Concrete. 0.2-1.2' Gray, angular, fine GRAVEL, some sand, loose, moist (base coarse fill).
	SM			1.2-6.3' Brown, silty, fine SAND, loose, moist (fill).
5		15 15 10		
	SP		1.2	6.3-8.0' Grayish brown, fine SAND, loose, moist.
	SM			8.0-13.0' Gray, silty, fine SAND, loose, moist. Wet below 9.0 feet. Scattered layers (~1") of silt below 10.0 feet.
10		4 3 10	1.0	
	SP			13.0'- Gray, fine SAND, loose, wet.
15		15 24 26	1.1	
20		9 10 11	0.1	Bottom of boring at 21.5 feet



KCSlip4 41430

SEA407960

ERM
915 118th Avenue S.E.
Suite 130
Bellevue, WA 98005
(425) 462-8591

BOREHOLE LOG

Site Id: MW-10

Project Number: 6051.31
Project Name: Seattle Air National Guard
Location: Seattle, WA
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 08/27/98
Total Depth: 21.50'
Completed Depth: 20.00'
Borehole Dia.: 4.25in

Ground Surface Elevation: 15.34'
Top of Casing Elevation: 14.97'
X Coordinate: 5644.90
Y Coordinate: 5321.36
Static Water Level: 10.00'

Blank Casing: type:Sch 40 PVC		dia:2.00in	fm: 0.0'	to: 0.00'
Screens: type:Slotted	size:0.010in	dia:2.00in	fm: 0.00'	to: 2.00'
Annular Fill: type:Concrete			fm: 0.00'	to: 2.00'
type:Bentonite			fm: 2.00'	to: 4.00'
type:10-20 Silica Sand			fm: 4.00'	to: 21.50'

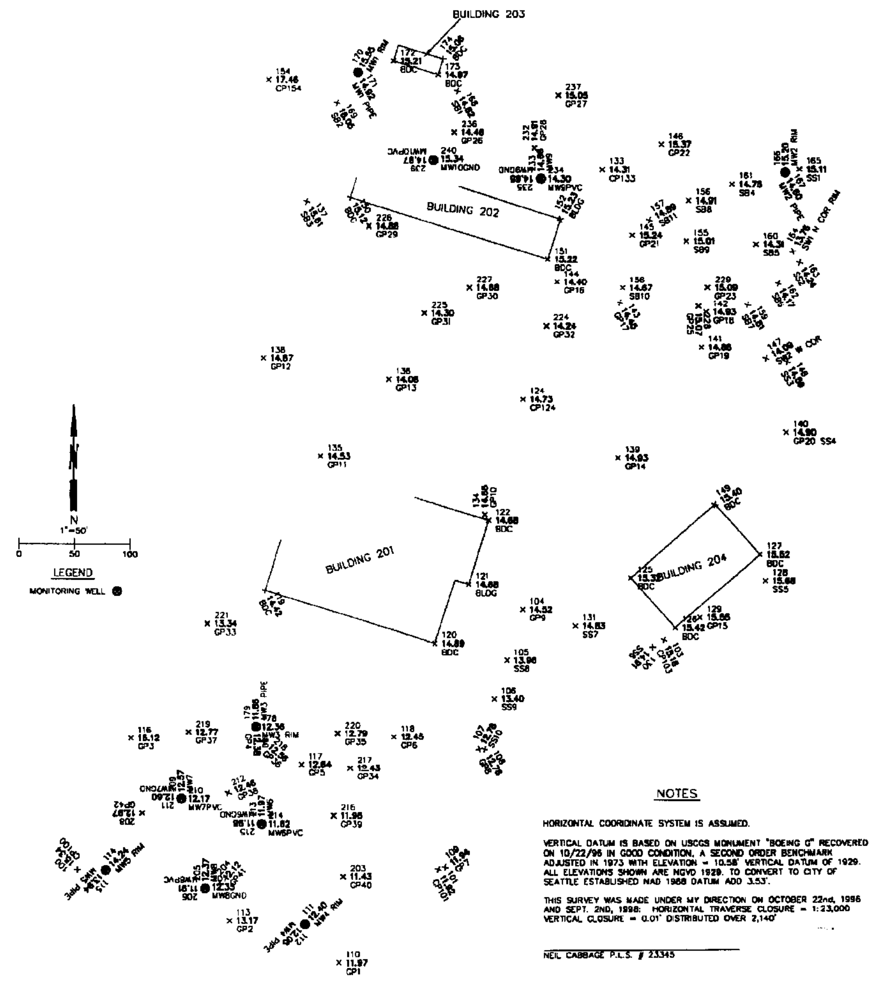
Depth (ft)	USCS Code	Blow Counts	PID (ppm)	Description/Soil Classification
0	ML			0.0-3.5' Dark brown SILT, some fine sand, soft, moist (fill).
				Roots, trace gravel below 2.0 feet.
	SM			3.5-5.8' Brown, silty, fine SAND, moist, loose, (fill).
5	SP	14 8 6	0.2	5.8-10.5' Brownish gray, fine SAND, moist, loose.
10				Wet below 10.0 feet.
	SM	6 8 13		10.5-11.5' Brown, silty, fine SAND, wet, loose.
	SP		0.2	11.5'- Gray, fine SAND, wet, loose.
				Fine to medium SAND, trace gravel below 13 feet.
15		9 12 15	0.3	
20		6 10 13	0.4	Bottom of boring at 21.5 feet.

KCSlip4 41431

SEA407961

APPENDIX C

LAND SURVEY DATA



NOTES

HORIZONTAL COORDINATE SYSTEM IS ASSUMED.

VERTICAL DATUM IS BASED ON USCGS MONUMENT "BOEING G" RECOVERED ON 10/22/96 IN GOOD CONDITION, A SECOND ORDER BENCHMARK ADJUSTED IN 1973 WITH ELEVATION = 10.58' VERTICAL DATUM OF 1929. ALL ELEVATIONS SHOWN ARE NGVD 1929. TO CONVERT TO CITY OF SEATTLE ESTABLISHED NAD 1988 DATUM ADD 3.53'.

THIS SURVEY WAS MADE UNDER MY DIRECTION ON OCTOBER 22nd, 1996 AND SEPT. 2ND, 1998: HORIZONTAL TRAVERSE CLOSURE = 1:23,000 VERTICAL CLOSURE = 0.01' DISTRIBUTED OVER 2,140'

NEIL CABBAGE P.L.S. # 23345

APPROVAL		PREPARED BY LANDMARK INC. 1130 140TH AVENUE N.E. ST.200 BELLEVUE, WASH. 98005 (206) 340 1100			OWNER	ERM-WEST	SHEET 1
DATE 9/14/98					PROJECT	SEATTLE ANGS	OF 1
JOB NO.		DESIGNED BY	DRAWN BY NSC	CHECKED BY	SHEET CONTENT	MONITORING LOCATIONS	

S:\PROJECT\ERM\seattle\Topo.dwg 01/04/99 gje 1.000=100.000

KCSlip4 41433

SEA407963

APPENDIX D

INVESTIGATION-DERIVED WASTE MANAGEMENT

APPENDIX D

INVESTIGATION-DERIVED WASTE MANAGEMENT

Soil cuttings and decontamination water generated during drilling and direct-push boring activities, and purge water and decontamination water generated during groundwater sampling, were collected and stored in 55-gallon drums. Each investigation-derived waste (IDW) drum was marked with a description of the drum contents. The contents of the IDW drums were designated as dangerous or non-dangerous waste in accordance with Washington State Dangerous Waste Regulations, Washington Administrative Code (WAC) Chapter 173-303. The waste designation for soil cuttings, purge water, and non-methanol-containing decontamination water was based on the analytical results for soil and groundwater samples collected during the Phase II RI. The methanol/rinse-water mixture generated in July, August, and September 1998, before isopropanol replaced methanol for the final decontamination spray rinse, was designated as an F003-listed dangerous waste per WAC 173-303. This mixture was contained in a separate drum, labeled as a dangerous waste, and stored on site in the Station's hazardous waste accumulation area.

The soil cuttings, purge water, and decontamination water generated in July-September 1998 (with the exception of the methanol/rinse-water mixture), and the purge water and decontamination water generated during subsequent quarterly groundwater sampling events, were determined not to be a Washington-defined dangerous waste. The soil drums were removed for disposal by the Defense Reutilization and Marketing Office at Fort Lewis, Washington. Non-dangerous purge water and decontamination water was discharged to the sanitary sewer. The drum containing the methanol/rinse-water mixture was disposed of at Burlington Environmental's wastewater treatment facility in Kent, Washington.

APPENDIX E

REPOSITORIES OF LABORATORY ANALYTICAL DATA PACKAGES

5/28/97

Landmark Inc., Bellevue, Wa.
1130 140th Ave NE Suite 200
Bellevue, Wa. 98005

ATTN: Steve Becker
ERM-West, Inc
455 Capitol Mall, Suite 800
Sacramento, Calif. 95814

Seattle ANGB survey data collected on 5/27/97:

Well BS005PZ
- 14.74' Ground
- 14.39' top PVC
- 14.80' North rim casing

Well BS006PZ
- 14.78' Ground
- 14.59' top PVC
- 15.07' South rim casing

Well BS004PZ
- 14.88' Asphalt
- 14.66' top PVC
- 15.03' North rim casing

NOTE: Location and elevation of SW-1 and SW-2 requested for this survey was previously obtained and shown on mapping supplied in 1996 (points numbered 147 and 164 in electronic file).

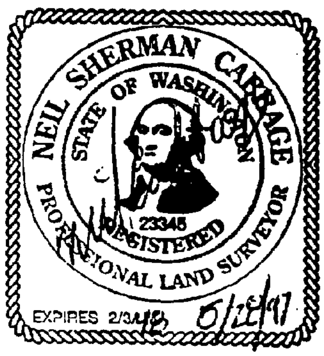
Everett ANGB survey data collected on 5/27/97:

Well ST005PZ
- 599.18' Asphalt
- 598.86' top PVC
- 599.26' North rim casing

Well ST004PZ
- 598.46' Ground
- 598.19' top PVC
- 598.54' North rim casing

Well SDO-005PZ
- 583.29' Asphalt
- 583.00' top PVC
- 583.40' North rim casing

Well SDO-009PZ
- 589.31' Asphalt
- 588.99' top PVC
- 589.35' North rim casing



Copies of the original laboratory data packages are available for public examination at two storage repositories. The repository location, address, and appropriate contact persons are listed below:

Repository Location	Address	Contact Person, Phone Number, and Facsimile Number
Washington Air National Guard, Tacoma, Washington	241 CES/CEV 104 Air Defense Lane Camp Murray, Washington 98430-5022	Mr. Stephen Purvine Phone: 253-512-3205 Facsimile: 253-512-3200
Environmental Resources Management	915 118th Avenue SE, Suite 130 Bellevue, Washington 98005	Mr. Rob Leet Phone: 425-462-8591 Facsimile: 425-455-3573

APPENDIX F

QUALITY CONTROL DATA REVIEW/VALIDATION REPORTS

APPENDIX F.1

QUALITY CONTROL DATA REVIEW/VALIDATION REPORT - AUGUST-SEPTEMBER 1998 SOIL AND GROUNDWATER DATA

Analytical data are the basis for evaluating the environmental conditions at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. A primary objective of environmental sampling conducted at the site is to obtain accurate data that reflect actual conditions.

This report addresses soil and groundwater analytical data collected in August and September 1998 at the Seattle ANGS during the Phase II Remedial Investigation (RI). To ensure that data quality was acceptable for decision-making purposes, analytical data for this project were reviewed and/or validated. This process identifies limitations on the use of the data, or data that should not be used for decision-making purposes. The quality of the data was assessed and any necessary qualifiers were applied following the *United States Environmental Protection Agency (USEPA) Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994).

Environmental Resources Management (ERM) reviewed and/or validated data for compliance with the following quality assurance/quality control (QA/QC) project- and/or method-prescribed criteria:

- Holding Time: The period of time between collection of the sample and preparation/analysis of the sample. Analyses performed for this project have method-prescribed holding times.
- Calibration: The analysis of target analytes at a range of concentrations to develop a graphical plot of instrument response against the different analyte concentrations. An initial calibration curve establishes the graphical plot, and the continuing calibration verification monitors daily instrument linearity against the initial calibration.

- Blank Samples: The preparation and analysis of samples from reagent (contaminant-free) water. Blank samples for this investigation included method, trip, rinsate, and field blanks. Detections in a blank sample indicate laboratory, handling, or field contamination.

- Internal Standards: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. The internal standards are used to quantitatively and qualitatively evaluate retention time and instrument response for each analytical run.

- Spike Samples: The preparation and analysis of an environmental sample or a sample of reagent water spiked with a subset of target analytes at known concentrations. The results of the spike analysis measure laboratory accuracy in the reagent sample, and results from the environmental sample spike measure potential interferences from the sample matrix.

- Surrogate Spikes: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. Surrogate spikes measure possible interferences from the sample matrix for the analysis of target analytes.

- Duplicate Samples: The preparation and analysis of an additional aliquot of the sample. The results from duplicate analysis measure potential heterogeneity of contaminant concentrations in the samples.

The following data qualifiers were used as appropriate during this review and validation process:

U: The analyte was analyzed for, but was not detected above the reported quantitation limit.

J: The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

N: The analysis indicated the presence of an analyte for which there was presumptive evidence to make a "tentative identification."

NJ: The analysis indicated the presence of an analyte that was "tentatively identified" and the associated numerical value represents its approximate concentration.

UJ: The analyte was not detected above the reported sample quantitation limit; however, the reported quantitation limit was

approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R: The sample results were rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte could not be verified.

None of the August-September 1998 soil or groundwater data were rejected based on the data review or validation. All of the data, including data flagged as having estimated values, are acceptable and can be used for decision-making purposes.

The following discussion addresses the results of the data review and validation for each of the QA/QC components listed above.

Holding Time

The USEPA and Washington Department of Ecology (WDOE) have established maximum recommended holding times for the analyses performed on the Phase II RI soil and groundwater samples. Holding times extending beyond the maximum can negatively affect sample integrity (e.g., loss of volatile compounds, biodegradation), and impacted samples are qualified depending on the severity of the exceedence and the analytes of concern. Each of the sample analysis results was reviewed for compliance with the method-prescribed preparation and analysis holding times. None of the analyses were performed outside of the prescribed holding time. Accordingly, sample results were not compromised by an excessive period between sample collection and analysis.

Calibration Results

Before an analytical instrument is used for sample analysis, the instrument should be calibrated to within USEPA method specifications. The purpose of this calibration is to ensure that the instrument is appropriately responsive to measurable chemical concentrations. If an instrument is not properly calibrated, it may not be capable of producing acceptable quantitative, qualitative, and reproducible data. For example, positive detections of a given analyte could contain an undetermined degree of inaccuracy if the instrument is out of calibration, although the results may still be considered valid. In the case of non-detected (ND) analytes, the associated reporting limit would be similarly affected; however, such results would still be considered NDs.

Two types of calibration data were reviewed: initial calibration verification (ICV) and continuing calibration verification (CCV). The ICV consisted of standards that were analyzed at either three or five concentrations. These concentrations ranged from the reporting limit to the upper linear range of the instrument. The laboratory evaluated the ICVs using relative standard deviation (RSD). The reported RSDs were compared to the method-prescribed acceptance criteria during the data validation. Any data associated with an ICV that had target analytes with an RSD above the acceptable method-prescribed criteria were qualified either "J," estimated, for detected analytes, or "UJ," estimated detection limit, for ND analytes.

The CCV is analyzed either daily or every 12 hours to ensure the instrument response is still within method performance criteria for linearity. The CCV consisted of analyzing a standard at one concentration; the concentration of this standard was generally in the mid-range of the ICV standard concentrations. The laboratory calculated the percent difference (%D) between CCV and the ICV. The %Ds were compared to the method-prescribed acceptance criteria during the data validation. Any data associated with a CCV that had target analytes with a %D above the method-prescribed criteria were qualified either "J," estimated, for detected analytes, or "UJ," estimated detection limit, for ND analytes.

Vinyl acetate, acetone, 2-hexanone, methylene chloride, 4-methyl-2-pentanone, 2-butanone, and p-isopropyltoluene results for project samples listed on Table F.1-1 were qualified "UJ," estimated detection limit, based on an elevated RSD or %D. None of the other data required qualification based on ICV or CCV results.

Blank Samples

Blank samples are prepared in the laboratory or in the field and are carried through the analytical process. The purpose of a blank sample is to test for contamination resulting from laboratory, shipping, or other sample-handling activities. Blank samples are analyzed and evaluated for detections of target analytes. If target analytes are detected in a blank sample, these detections indicate that some element of the sample collection or analysis process has introduced contaminants not present in the original environmental sample aliquot. If target analytes are detected

TABLE F.1-1
Data Qualified Based on Calibration Results
143rd CCSQ, Seattle ANGS, Seattle, Washington

Data Package	Analytical Parameter	Calibration (ICV/CCV)	Date	Associated Samples	Target Compound	RSD or %D	ERM Qualifier*
808031	VOCs	ICV	7/27/98	GP-28-8.0	Vinyl acetate	29.3	UJ
				GP-27-8.0			UJ
				GP-26-8.0			UJ
				GP-25-8.0			UJ
				GP-25-8.0D			UJ
				GP-24-8.0			UJ
				GP-23-8.0			UJ
				GP-32-7.0			UJ
				GP-30-8.0			UJ
				GP-31-7.5			UJ
				GP-29-7.0			UJ
				GP-39-7.0			UJ
				GP-40-6.0			UJ
				GP-41-6.0			UJ
				GP-42-6.0			UJ
				GP-38-6.0			UJ
				GP-37-7.0			UJ
				GP-36-7.0			UJ
				GP-36-7.0D			UJ
				GP-35-7.0			UJ
				GP-34-7.0			UJ
				GP-33-8.0			UJ
		CCV	8/15/98	GP-28-8.0	Acetone	31.8	UJ
				GP-27-8.0	Vinyl acetate	26.8	UJ
				GP-26-8.0	2-Hexanone	26.1	UJ
				GP-25-8.0			UJ
				GP-25-8.0D			UJ
				GP-24-8.0			UJ
				GP-23-8.0			UJ
				GP-32-7.0			UJ
				GP-30-8.0			UJ
				GP-31-7.5			UJ
				GP-29-7.0			UJ
				GP-39-7.0			UJ
		CCV	8/17/98	GP-40-6.0	Methylene chloride	36.5	UJ
				GP-41-6.0	Vinyl acetate	26.4	UJ
				GP-42-6.0	p-Isopropyltoluene	27.6	UJ
				GP-38-6.0			UJ
				GP-37-7.0			UJ
				GP-36-7.0			UJ
				GP-36-7.0D			UJ
				GP-35-7.0			UJ
				GP-34-7.0			UJ
				GP-33-8.0			UJ
809005	VOCs	CCV	9/14/98	TB090198	Acetone	44.6	UJ
				MW-1-98-1	2-Butanone	34.6	UJ
				MW10-98-1	4-Methyl-2-pentanone	27.4	UJ
				MW-9-98-1	2-Hexanone	39.6	UJ
				BS-005PZ-98-1			UJ

TABLE F.1-1

Data Qualified Based on Calibration Results
143rd CCSQ, Seattle ANGS, Seattle, Washington

Data Package	Analytical Parameter	Calibration (ICV/CCV)	Date	Associated Samples	Target Compound	RSD or %D	ERM Qualifier*
809007	VOCs	CCV	9/13/98	BS-006PZ-98-1	Acetone	48	UJ
				TB090298	2-Butanone	44.3	UJ
				MW-2-98-1	4-Methyl-2-pentanone	35.8	UJ
				MW-7-98-1	2-Hexanone	42.4	UJ
				MW-3-98-1			UJ
				MW-3-98-1D			UJ
				MW-3-98-1R			UJ
				MW-5-98-1			UJ
				MW-6-98-1			UJ
		CCV	9/14/98	MW-8-98-1	Acetone	44.6	UJ
				MW-4-98-1	2-Butanone	34.6	UJ
				BS-004PZ-98-1	4-Methyl-2-pentanone	27.4	UJ
				BS-004PZ-98-1FA	2-Hexanone	39.6	UJ
				BS-004PZ-98-1FT			UJ

ICV - Initial calibration verfication
CCV - Continuing calibration verification
D - Duplicate sample
FA - Field Blank prepared using ASTM Type II water
FT - Field Blank prepared using tap water
J - The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
R - Rinsate blank
UJ - The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
VOCs - Volatile organic compounds
%D - Percent difference
RSD - Relative standard deviation
*Data qualifiers applied to affected sample data points indicated.

in a blank sample, then all associated data must be evaluated to determine whether:

- Those data have been similarly impacted; or
- The blank detections are an isolated occurrence not representative of other data.

The four types of blank samples analyzed and reported with the soil and groundwater samples collected in August and September 1998 were method, trip, rinsate, and field blank samples. Preparation, handling, and analysis of these blank samples are summarized below.

1. Method blank samples monitor for potential laboratory contamination of samples. Method blank samples were prepared in the laboratory by taking an aliquot of reagent water or soil through all preparation and analysis steps. A method blank was prepared and analyzed with each batch of environmental samples.

2. Trip blank samples monitor for potential contamination of samples during collection and transportation to the laboratory. Trip blank samples were prepared by filling a volatile organics analysis (VOA) vial with an aliquot of reagent water and sealing it with a Teflon-lined-septum lid. The trip blank sample travels with the filled aqueous and soil sample containers to the laboratory.

3. Rinsate blank samples monitor for potential contamination of project samples from inadequate decontamination of sample collection equipment. Rinsate blank samples were prepared in the field by pouring American Society for Testing and Materials (ASTM) Type II reagent-grade water over the decontaminated sample collection equipment. The water was collected in clean sample containers supplied by the laboratory. Rinsate blank samples were labeled with an "R" identifier at the end of the sample ID.

4. Field blank samples monitor for potential contamination of project samples from ambient conditions at the sample collection site. Field blank samples were prepared at sample collection locations by slowly pouring tap water or ASTM Type II water into clean sample containers supplied by the laboratory. Field blank samples prepared with tap water were labeled with an "FT" identifier at the end of the sample ID. The identifier "FA" was used to designate field blank samples prepared with ASTM Type II water.

No target analytes were detected in any of the method blank samples. The common drinking water contaminant chloroform was reported in two tap water field blanks, one trip blank, one rinsate blank, and one project groundwater sample. Following USEPA Functional Guidelines[1], the positive detection of chloroform in groundwater sample MW-2-98-1 was qualified "U," ND. None of the other data required qualification based on blank results.

Spike Samples

A spike sample is a QC sample that is prepared and analyzed by the laboratory. The laboratory prepares, analyzes, and reports spike sample results to demonstrate their ability to properly analyze, detect, and quantify target analytes. A spike sample result is typically reported as the amount of analyte detected divided by the known amount spiked into the sample, and is commonly referred to as percent recovery. The percent recovery is then compared to an established limit range. [2] The two types of spike samples analyzed with the project samples were matrix and blank spikes.

1. Matrix spike (MS) samples consist of an aliquot of an environmental sample that is spiked with known concentrations of a subset of target analytes. A matrix spike duplicate (MSD) sample is a second (duplicate) spike sample prepared and analyzed with the MS sample. MS samples are used to monitor potential interference from the sample matrix for target analytes. A low MS recovery may indicate low-biased sample results; a high MS recovery may indicate high-biased sample results.

2. Blank spike samples, commonly referred to as laboratory control samples (LCS), consist of an aliquot of reagent water or soil that is spiked with known concentrations of a subset of target analytes. The LCS sample is used to monitor laboratory accuracy without the bias of a sample matrix. LCS recoveries outside of acceptable limits may indicate poor laboratory accuracy.

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[1] The USEPA *Contract Laboratory Program National Functional Guidelines* state "Any volatile compound detected in the sample (other than the common volatile laboratory contaminants), that was also detected in any associated blank, is qualified if the sample concentration is less than five times (5x) the blank concentration.."

[2] In most cases, the prescribed analytical method will specify protocol to develop appropriate limit ranges. In some cases, however, limit ranges are established by the laboratory in the method procedures.

All of the MS and LCS recoveries were within acceptable limits. The acceptable MS and LCS recoveries indicate minimal matrix interference and acceptable laboratory accuracy for the August-September 1998 soil and groundwater data.

Internal Standard Responses

Under USEPA methods, a given analyte list for organic compounds is segregated by chemical properties and retention time into one or more subsets. A USEPA-defined internal standard with comparable chemical properties and retention times is assigned to each subset of analytes. The laboratory adds a known concentration of an internal standard to each sample, including laboratory QC samples (e.g., calibration standards, MS, method blank samples), prior to analysis. The instrument internal standard response for each sample is compared to the internal standard response in the daily CCV. The sample internal standard area count must be within the range of 0.5 to 2 times the CCV area count, and the retention time must be within ±30 seconds of the CCV retention time. If the area count and/or retention time measured for the sample is outside the acceptable range, quantitation results for the associated analyte subset may be biased. Interferences from the sample matrix are typically responsible for internal standard responses that are consistently outside acceptable ranges; most matrix interferences cause a consistently high or low bias.

Internal standards were added to each of the project samples analyzed for VOCs. All of the internal standard responses were within acceptable limits, indicating minimal matrix interference and acceptable sample quantitation.

Surrogate Spikes

A surrogate spike is similar to an internal standard; it is chemically similar to the target analytes and is only used in organic analyses. The difference between surrogate spikes and internal standards is that surrogate spikes are used only to assess possible interferences from the sample matrix, whereas internal standards are used to quantitate target analytes while accounting for any interferences from the sample matrix. Surrogate spike results are typically reported in terms of percent recovery, which is calculated by dividing the amount of surrogate detected in the sample by the known amount of surrogate added to the sample.

For the August-September 1998 soil and groundwater data, surrogate recoveries were compared to the laboratory-generated limits of acceptance. The surrogate recoveries were within acceptable limits, indicating that sample results were subject to minimal interferences from the sample matrix.

Duplicate Samples

A duplicate sample is a second aliquot of a sample that is treated the same as the primary sample. A duplicate sample analysis is performed to measure the precision of the method and possible heterogeneity of analyte concentrations in the sample matrix. Duplicate field samples are collected to measure matrix heterogeneity.

Laboratory duplicate analyses for the project samples consisted of matrix spike duplicate analyses. The laboratory calculated the relative percent difference (RPD) between the two detected values as applicable. The calculated RPDs were compared to method-prescribed or laboratory-generated acceptable limits. Field duplicate samples also were collected and submitted for analysis. No target analytes were detected in the field duplicate samples or the associated primary samples.

The duplicate sample RPDs were within acceptable limits. The laboratory RPDs and field duplicate sample results indicate acceptable analytical accuracy and minimal matrix heterogeneity.

Overall Assessment

None of the Seattle ANGS Phase II RI analytical data for samples collected in August and September 1998 were rejected. The data set is 100 percent complete and meets the project goal for completeness. Qualified data can be used for decision-making purposes; however, the limitations identified by the qualifiers should be considered when using the data. The quality of the August-September 1998 soil and groundwater analytical data is acceptable for the preparation of technically defensible documents.

APPENDIX F.2

QUALITY CONTROL DATA VALIDATION REPORT - NOVEMBER 1998 GROUNDWATER DATA

Analytical data are the basis for evaluating the environmental conditions at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. A primary objective of environmental sampling conducted at the site is to obtain accurate data that reflect actual conditions.

This report addresses groundwater analytical data collected in November 1998 at the Seattle ANGS during the Phase II Remedial Investigation (RI). Eighteen groundwater samples were analyzed for volatile organic analytes using United States Environmental Protection Agency (USEPA) Method 8260. To ensure that data quality was acceptable for decision-making purposes, analytical data for this project were validated. This process identifies limitations on the use of the data, or data that should not be used for decision-making purposes. The quality of the data was assessed and any necessary qualifiers were applied following the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994).

Environmental Resources Management (ERM) validated data for compliance with the following quality assurance/quality control (QA/QC) project- and/or method-prescribed criteria:

- Holding Time: The period of time between collection of the sample and preparation/analysis of the sample. Analyses performed for this project have method-prescribed holding times.

- Calibration: The analysis of target analytes at a range of concentrations to develop a graphical plot of instrument response against the different analyte concentrations. An initial calibration curve establishes the graphical plot, and the continuing calibration verification monitors daily instrument linearity against the initial calibration.

- Blank Samples: The preparation and analysis of samples from reagent (contaminant-free) water. Blank samples for this investigation included method, trip, rinsate, and field blanks. Detections in a blank sample indicate laboratory, handling, or field contamination.

- Internal Standards: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. The internal standards are used to quantitatively and qualitatively evaluate retention time and instrument response for each analytical run.

- Spike Samples: The preparation and analysis of an environmental sample or a sample of reagent water spiked with a subset of target analytes at known concentrations. The results of the spike analysis measure laboratory accuracy in the reagent sample, and results from the environmental sample spike measure potential interferences from the sample matrix.

- Surrogate Spikes: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. Surrogate spikes measure possible interferences from the sample matrix for the analysis of target analytes.

- Duplicate Samples: The preparation and analysis of an additional aliquot of the sample. The results from duplicate analysis measure potential heterogeneity of contaminant concentrations in the samples.

The following data qualifiers were used as appropriate during this validation process:

U: The analyte was analyzed for, but was not detected above the reported quantitation limit.

J: The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

N: The analysis indicated the presence of an analyte for which there was presumptive evidence to make a "tentative identification."

NJ: The analysis indicated the presence of an analyte that was "tentatively identified" and the associated numerical value represents its approximate concentration.

UJ: The analyte was not detected above the reported sample quantitation limit; however, the reported quantitation limit was

approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R: The sample results were rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte could not be verified.

None of the November 1998 groundwater data were rejected or qualified based on the data validation. All of the data are acceptable and can be used for decision-making purposes.

The following discussion addresses the results of the data validation for each of the QA/QC components listed above.

Holding Time

The USEPA has established maximum recommended holding times for the analyses performed on the Phase II RI groundwater samples. Holding times extending beyond the maximum can negatively affect sample integrity (e.g., loss of volatile compounds, biodegradation), and impacted samples are qualified depending on the severity of the exceedence and the analytes of concern. The maximum holding time for USEPA Method 8260 is 14 days from the date of collection for preserved samples and 7 days from date of collection for unpreserved samples. Each of the sample analysis results was reviewed for compliance with the method-prescribed preparation and analysis holding times. None of the analyses were performed outside of the prescribed holding time. Accordingly, sample results were not compromised by an excessive period between sample collection and analysis.

Calibration Results

Before an analytical instrument is used for sample analysis, the instrument should be calibrated to within USEPA method specifications. The purpose of this calibration is to ensure that the instrument is appropriately responsive to measurable chemical concentrations. If an instrument is not properly calibrated, it may not be capable of producing acceptable quantitative, qualitative, and reproducible data. For example, positive detections of a given analyte could contain an undetermined degree of inaccuracy if the instrument is out of calibration, although the results may still be considered valid. In the case of non-detected (ND) analytes, the associated reporting limit would be similarly affected; however, such results would still be considered NDs.

Two types of calibration data were reviewed: initial calibration verification (ICV) and continuing calibration verification (CCV). The ICV consisted of standards that were analyzed at five or more concentrations. These concentrations ranged from the reporting limit to the upper linear range of the instrument. Average response factors from the ICV were used to calculate sample results. The laboratory evaluated the ICVs using relative standard deviation (RSD). The reported RSDs were compared to the method-prescribed acceptance criteria during the data validation. None of the ICV RSDs exceeded the acceptable method-prescribed criteria. Accordingly, none of the data were qualified based on the initial calibration results.

The CCV is analyzed either daily or every 12 hours to ensure the instrument response is still within method performance criteria for linearity. The CCV consisted of analyzing a standard at one concentration; the concentration of this standard was generally in the mid-range of the ICV standard concentrations. The laboratory calculated the percent difference (%D) between CCV and the ICV. The %Ds were compared to the method-prescribed acceptance criteria during the data validation. The CCV %Ds were below the method-prescribed criteria; accordingly, none of the data were qualified based on the CCV results.

Blank Samples

Blank samples are prepared in the laboratory or in the field and are carried through the analytical process. The purpose of a blank sample is to test for contamination resulting from laboratory, shipping, or other sample-handling activities. Blank samples are analyzed and evaluated for detections of target analytes. If target analytes are detected in a blank sample, these detections indicate that some element of the sample collection or analysis process has introduced contaminants not present in the original environmental sample aliquot. If target analytes are detected in a blank sample, then all associated data must be evaluated to determine whether:

- Those data have been similarly impacted; or
- The blank detections are an isolated occurrence not representative of other data.

The four types of blank samples analyzed and reported with the groundwater samples collected in November 1998 were method, trip, rinsate, and field blank samples. Preparation, handling, and analysis of these blank samples are summarized below.

1. Method blank samples monitor for potential laboratory contamination of samples. Method blank samples were prepared in the laboratory by taking an aliquot of reagent water through all preparation and analysis steps. A method blank was prepared and analyzed with each batch of environmental samples.

2. Trip blank samples monitor for potential contamination of samples during collection and transportation to the laboratory. Trip blank samples were prepared by filling a volatile organics analysis (VOA) vial with an aliquot of reagent water and sealing it with a Teflon-lined-septum lid. The trip blank sample travels with the filled aqueous sample containers to the laboratory.

3. Rinsate blank samples monitor for potential contamination of project samples from inadequate decontamination of sample collection equipment. Rinsate blank samples were prepared in the field by pouring American Society for Testing and Materials (ASTM) Type II reagent-grade water over the decontaminated sample collection equipment. The water was collected in clean sample containers supplied by the laboratory. Rinsate blank samples were labeled with an "R" identifier at the end of the sample ID.

4. Field blank samples monitor for potential contamination of project samples from ambient conditions at the sample collection site. Field blank samples were prepared at sample collection locations by slowly pouring tap water or ASTM Type II water into clean sample containers supplied by the laboratory. Field blank samples prepared with tap water were labeled with an "FT" identifier at the end of the sample ID. The identifier "FA" was used to designate field blank samples prepared with ASTM Type II water.

No target analytes were detected in any of the method blank samples. The common drinking water contaminants chloroform and bromodichloromethane were reported in the tap water field blank sample. None of the data required qualification based on blank results.

Spike Samples

A spike sample is a QC sample that is prepared and analyzed by the laboratory. The laboratory prepares, analyzes, and reports spike sample results to demonstrate their ability to properly analyze, detect, and quantify target analytes. A spike sample result is typically reported as the amount of analyte detected divided by the known amount spiked into the sample, and is commonly referred to as percent recovery. The percent recovery is then compared to an established limit range. [1] The two types of spike samples analyzed with the project samples were matrix and blank spikes.

1. Matrix spike (MS) samples consist of an aliquot of an environmental sample that is spiked with known concentrations of a subset of target analytes. A matrix spike duplicate (MSD) sample is a second (duplicate) spike sample prepared and analyzed with the MS sample. MS samples are used to monitor potential interference from the sample matrix for target analytes. A low MS recovery may indicate low-biased sample results; a high MS recovery may indicate high-biased sample results.

2. Blank spike samples, commonly referred to as laboratory control samples (LCS), consist of an aliquot of reagent water that is spiked with known concentrations of a subset of target analytes. The LCS sample is used to monitor laboratory accuracy without the bias of a sample matrix. LCS recoveries outside of acceptable limits may indicate poor laboratory accuracy.

All of the MS and LCS recoveries were within acceptable limits. The acceptable MS and LCS recoveries indicate minimal matrix interference and acceptable laboratory accuracy for the November 1998 groundwater data.

Internal Standard Responses

Under USEPA methods, a given analyte list for organic compounds is segregated by chemical properties and retention time into one or more subsets. A USEPA-defined internal standard with comparable chemical properties and retention times is assigned to each subset of analytes. The

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[1] In most cases, the prescribed analytical method will specify protocol to develop appropriate limit ranges. In some cases, however, limit ranges are established by the laboratory in the method procedures.

laboratory adds a known concentration of an internal standard to each sample, including laboratory QC samples (e.g., calibration standards, MS, method blank samples), prior to analysis. The instrument internal standard response for each sample is compared to the internal standard response in the daily CCV. The sample internal standard area count must be within the range of 0.5 to 2 times the CCV area count, and the retention time must be within ±30 seconds of the CCV retention time. If the area count and/or retention time measured for the sample is outside the acceptable range, quantitation results for the associated analyte subset may be biased. Interferences from the sample matrix are typically responsible for internal standard responses that are consistently outside acceptable ranges; most matrix interferences cause a consistently high or low bias.

Internal standards were added to each of the project samples analyzed for VOCs. All of the internal standard responses were within acceptable limits, indicating minimal matrix interference and acceptable sample quantitation.

Surrogate Spikes

A surrogate spike is similar to an internal standard; it is chemically similar to the target analytes and is only used in organic analyses. The difference between surrogate spikes and internal standards is that surrogate spikes are used only to assess possible interferences from the sample matrix, whereas internal standards are used to quantitate target analytes while accounting for any interferences from the sample matrix. Surrogate spike results are typically reported in terms of percent recovery, which is calculated by dividing the amount of surrogate detected in the sample by the known amount of surrogate added to the sample.

For the November 1998 groundwater data, surrogate recoveries were compared to the laboratory-generated limits of acceptance. The surrogate recoveries were within acceptable limits, indicating that sample results were subject to minimal interferences from the sample matrix.

Duplicate Samples

A duplicate sample is a second aliquot of a sample that is treated the same as the primary sample. A duplicate sample analysis is performed to measure the precision of the method and possible heterogeneity of analyte concentrations in the sample matrix. Duplicate field samples are collected to measure matrix heterogeneity.

Laboratory duplicate analyses for the project samples consisted of matrix spike duplicate analyses. The laboratory calculated the relative percent difference (RPD) between the two detected values as applicable. The calculated RPDs were compared to method-prescribed or laboratory-generated acceptable limits. A field duplicate sample also was collected and submitted for analysis. No target analytes were detected in the field duplicate samples or the associated primary samples.

The duplicate sample RPDs were within acceptable limits. The laboratory RPDs and field duplicate sample results indicate acceptable analytical accuracy and minimal matrix heterogeneity.

Overall Assessment

None of the Seattle ANGS Phase II RI analytical data for samples collected in November 1998 were qualified or rejected. The data set is 100 percent complete and meets the project goal for completeness. The November 1998 groundwater analytical data can be used for decision-making purposes, and the quality of the data is acceptable for the preparation of technically defensible documents.

APPENDIX F.3

QUALITY CONTROL DATA VALIDATION REPORT - FEBRUARY 1999 GROUNDWATER DATA

Analytical data are the basis for evaluating the environmental conditions at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. A primary objective of environmental sampling conducted at the site is to obtain accurate data that reflect actual conditions.

This report addresses groundwater analytical data collected in February 1999 at the Seattle ANGS during the Phase II Remedial Investigation (RI). Eighteen groundwater samples were analyzed for volatile organic analytes using United States Environmental Protection Agency (USEPA) Method 8260. To ensure that data quality was acceptable for decision-making purposes, analytical data for this project were validated. This process identifies limitations on the use of the data, or data that should not be used for decision-making purposes. The quality of the data was assessed and any necessary qualifiers were applied following the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994).

Environmental Resources Management (ERM) validated data for compliance with the following quality assurance/quality control (QA/QC) project- and/or method-prescribed criteria:

- Holding Time: The period of time between collection of the sample and preparation/analysis of the sample. Analyses performed for this project have method-prescribed holding times.
- Calibration: The analysis of target analytes at a range of concentrations to develop a graphical plot of instrument response against the different analyte concentrations. An initial calibration curve establishes the graphical plot, and the continuing calibration verification monitors daily instrument linearity against the initial calibration.

- Blank Samples: The preparation and analysis of samples from reagent (contaminant-free) water. Blank samples for this investigation included method, trip, rinsate, and field blanks. Detections in a blank sample indicate laboratory, handling, or field contamination.

- Internal Standards: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. The internal standards are used to quantitatively and qualitatively evaluate retention time and instrument response for each analytical run.

- Spike Samples: The preparation and analysis of an environmental sample or a sample of reagent water spiked with a subset of target analytes at known concentrations. The results of the spike analysis measure laboratory accuracy in the reagent sample, and results from the environmental sample spike measure potential interferences from the sample matrix.

- Surrogate Spikes: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. Surrogate spikes measure possible interferences from the sample matrix for the analysis of target analytes.

- Duplicate Samples: The preparation and analysis of an additional aliquot of the sample. The results from duplicate analysis measure potential heterogeneity of contaminant concentrations in the samples.

The following data qualifiers were used as appropriate during this validation process:

U: The analyte was analyzed for, but was not detected above the reported quantitation limit.

J: The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

N: The analysis indicated the presence of an analyte for which there was presumptive evidence to make a "tentative identification."

NJ: The analysis indicated the presence of an analyte that was "tentatively identified" and the associated numerical value represents its approximate concentration.

UJ: The analyte was not detected above the reported sample quantitation limit; however, the reported quantitation limit was

approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R: The sample results were rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte could not be verified.

None of the February 1999 groundwater data were rejected based on the data validation. All of the data, including data flagged as having estimated values, are acceptable and can be used for decision-making purposes.

The following discussion addresses the results of the data validation for each of the QA/QC components listed above.

Holding Time

The USEPA has established maximum recommended holding times for the analyses performed on the Phase II RI groundwater samples. Holding times extending beyond the maximum can negatively affect sample integrity (e.g., loss of volatile compounds, biodegradation), and impacted samples are qualified depending on the severity of the exceedence and the analytes of concern. The maximum holding time for USEPA Method 8260 is 14 days from the date of collection for preserved samples and 7 days from date of collection for unpreserved samples. Each of the sample analysis results was reviewed for compliance with the method-prescribed preparation and analysis holding times.

None of the initial analyses were performed outside of the prescribed holding time. Three samples were reanalyzed one day after the holding time had expired, to confirm out-of-limit surrogate recoveries. Consequently, the results from the second analysis were qualified "J," estimated, for detected compounds, and "UJ," estimated detection limit, for compounds that were not detected.

The results of the reanalysis were selected as secondary results; the initial analyses of these samples should be used for groundwater quality evaluations. Accordingly, sample results were not compromised by an excessive period between sample collection and analysis.

Calibration Results

Before an analytical instrument is used for sample analysis, the instrument should be calibrated to within USEPA method specifications. The purpose of this calibration is to ensure that the instrument is appropriately responsive to measurable chemical concentrations. If an instrument is not properly calibrated, it may not be capable of producing acceptable quantitative, qualitative, and reproducible data. For example, positive detections of a given analyte could contain an undetermined degree of inaccuracy if the instrument is out of calibration, although the results may still be considered valid. In the case of non-detected (ND) analytes, the associated reporting limit would be similarly affected; however, such results would still be considered NDs.

Two types of calibration data were reviewed: initial calibration verification (ICV) and continuing calibration verification (CCV). The ICV consisted of standards that were analyzed at five or more concentrations. These concentrations ranged from the reporting limit to the upper linear range of the instrument. Average response factors from the ICV were used to calculate sample results. The laboratory evaluated the ICVs using relative standard deviation (RSD). The reported RSDs were compared to the method-prescribed acceptance criteria during the data validation. Any data associated with an ICV that had target analytes with an RSD above the acceptable method-prescribed criteria were qualified either "J," estimated, for detected analytes, or "UJ," estimated detection limit, for ND analytes.

The CCV is analyzed either daily or every 12 hours to ensure the instrument response is still within method performance criteria for linearity. The CCV consisted of analyzing a standard at one concentration; the concentration of this standard was generally in the mid-range of the ICV standard concentrations. The laboratory calculated the percent difference (%D) between CCV and the ICV. The %Ds were compared to the method-prescribed acceptance criteria during the data validation. Any data associated with a CCV that had target analytes with a %D above the method-prescribed criteria were qualified either "J," estimated, for detected analytes, or "UJ," estimated detection limit, for ND analytes.

The results for the target compounds and project samples listed on Table F.3-1 were qualified "UJ," estimated detction limit, based on an elevated RSD or %D. None of the other data required qualification based on ICV or CCV results.

TABLE F.3-1
Data Qualified Based on Calibration Results
143rd CCSQ, Seattle ANGS, Seattle, Washington

Data Package	Analytical Parameter	Calibration (ICV/CCV)	Date	Associated Samples	Target Compound	RSD or %D	ERM Qualifier*
902035	VOCs	ICV	2/4/99	All those listed	Chloroethane	20.5	UJ
				below.	trans-1,2-Dichloroethane	18.4	UJ
		CCV	3/9/99	TB022499-1	Chloromethane	21.0	UJ
				BS-006PZ-99-1	Chloroethane	28.7	UJ
				MW-9-99-1	Acetone	51.4	UJ
				MW-10-99-1	Vinyl Acetate	48.4	UJ
				MW-1-99-1	2-Butanone	36.1	UJ
				BS-005PZ-99-1	1,2-Dichloroethane	28.1	UJ
					cis-1,3-Dichloropropene	25.1	UJ
					4-Methyl-2-Pentanone	26.5	UJ
					2-Hexanone	44.0	UJ
					Bromoform	26.6	UJ
		CCV	3/11/99	MW-6-99-1	Chloromethane	39.5	UJ
				MW-5-99-1	Vinyl Chloride	34.5	UJ
				TB022599-1	Chloroethane	42.6	UJ
				MW-3-99-1	Vinyl Acetate	110.9	UJ
				MW-7-99-1	cis-1,2-Dichloroethene	30.2	UJ
					1,2-Dichloroethane	24.9	UJ
					cis-1,3-Dichloropropene	38.7	UJ
					trans-1,3-Dichloropropene	26.6	UJ
					1,1,2,2,-Tetrachloroethene	57.9	UJ
					p-isopropyltoluene	21.5	UJ
		CCV	3/10/99	BS-004PZ-99-1	Chloromethane	24.7	UJ
				MW-2-99-1	Vinyl Chloride	23.2	UJ
				MW-8-99-1FT	Chloroethane	36.5	UJ
				MW-98-99-1FA	Vinyl Acetate	37.6	UJ
				MW-8-99-1	1,2-Dichloroethane	25.9	UJ
				MW-8-99-1D	cis-1,3-Dichloropropene	29.0	UJ
				MW-4-99-1-R	1,1,2,2-Tetrachloroethane	34.6	UJ
				MW-4-99-1			
				MW-4-99-1D			

ICV= Initial calibration verification
CCV= Continuing calibration verification
RSD = Relative standard deviation
%D = Percent difference
VOCs = Volatile organic compounds
D = Duplicate sample
FA = Field blank prepared using ASTM Type II water
FT = Field blank prepared using tap water
UJ = Reported detection limits for the listed compounds and samples are estimated concentrations.
* Data qualifiers applied to affected sample data points indicated.

Blank Samples

Blank samples are prepared in the laboratory or in the field and are carried through the analytical process. The purpose of a blank sample is to test for contamination resulting from laboratory, shipping, or other sample-handling activities. Blank samples are analyzed and evaluated for detections of target analytes. If target analytes are detected in a blank sample, these detections indicate that some element of the sample collection or analysis process has introduced contaminants not present in the original environmental sample aliquot. If target analytes are detected in a blank sample, then all associated data must be evaluated to determine whether:

- Those data have been similarly impacted; or
- The blank detections are an isolated occurrence not representative of other data.

The four types of blank samples analyzed and reported with the groundwater samples collected in February 1999 were method, trip, rinsate, and field blank samples. Preparation, handling, and analysis of these blank samples are summarized below.

1. Method blank samples monitor for potential laboratory contamination of samples. Method blank samples were prepared in the laboratory by taking an aliquot of reagent water through all preparation and analysis steps. A method blank was prepared and analyzed with each batch of environmental samples.

2. Trip blank samples monitor for potential contamination of samples during collection and transportation to the laboratory. Trip blank samples were prepared by filling a volatile organics analysis (VOA) vial with an aliquot of reagent water and sealing it with a Teflon-lined-septum lid. The trip blank sample travels with the filled aqueous sample containers to the laboratory.

3. Rinsate blank samples monitor for potential contamination of project samples from inadequate decontamination of sample collection equipment. Rinsate blank samples were prepared in the field by pouring American Society for Testing and Materials (ASTM) Type II reagent-grade water over the decontaminated sample collection equipment. The water was collected in clean sample containers

supplied by the laboratory. Rinsate blank samples were labeled with an "R" identifier at the end of the sample ID.

4. Field blank samples monitor for potential contamination of project samples from ambient conditions at the sample collection site. Field blank samples were prepared at sample collection locations by slowly pouring tap water or ASTM Type II water into clean sample containers supplied by the laboratory. Field blank samples prepared with tap water were labeled with an "FT" identifier at the end of the sample ID. The identifier "FA" was used to designate field blank samples prepared with ASTM Type II water.

No target analytes were detected in any of the blank samples. None of the data required qualification based on the blank results.

Spike Samples

A spike sample is a QC sample that is prepared and analyzed by the laboratory. The laboratory prepares, analyzes, and reports spike sample results to demonstrate their ability to properly analyze, detect, and quantify target analytes. A spike sample result is typically reported as the amount of analyte detected divided by the known amount spiked into the sample, and is commonly referred to as percent recovery. The percent recovery is then compared to an established limit range. [1] The two types of spike samples analyzed with the project samples were matrix and blank spikes.

1. Matrix spike (MS) samples consist of an aliquot of an environmental sample that is spiked with known concentrations of a subset of target analytes. A matrix spike duplicate (MSD) sample is a second (duplicate) spike sample prepared and analyzed with the MS sample. MS samples are used to monitor potential interference from the sample matrix for target analytes. A low MS recovery may indicate low-biased sample results; a high MS recovery may indicate high-biased sample results.

2. Blank spike samples, commonly referred to as laboratory control samples (LCS), consist of an aliquot of reagent water that is spiked with known concentrations of a subset of target analytes. The LCS

[1] In most cases, the prescribed analytical method will specify protocol to develop appropriate limit ranges. In some cases, however, limit ranges are established by the laboratory in the method procedures.

sample is used to monitor laboratory accuracy without the bias of a sample matrix. LCS recoveries outside of acceptable limits may indicate poor laboratory accuracy.

All but two of the MS and LCS recoveries were within acceptable limits. The 1,1-dichloroethene and benzene recoveries of 135 and 121 percent, respectively, were above the upper control limits for the LCS analyzed on 10 March 1999. Neither of these compounds was reported in any of the associated samples, therefore none of the data required qualification. The acceptable MS and LCS recoveries indicate minimal matrix interference and acceptable laboratory accuracy for the February 1999 groundwater data.

Internal Standard Responses

Under USEPA methods, a given analyte list for organic compounds is segregated by chemical properties and retention time into one or more subsets. A USEPA-defined internal standard with comparable chemical properties and retention times is assigned to each subset of analytes. The laboratory adds a known concentration of an internal standard to each sample, including laboratory QC samples (e.g., calibration standards, MS, method blank samples), prior to analysis. The instrument internal standard response for each sample is compared to the internal standard response in the daily CCV. The sample internal standard area count must be within the range of 0.5 to 2 times the CCV area count, and the retention time must be within ±30 seconds of the CCV retention time. If the area count and/or retention time measured for the sample is outside the acceptable range, quantitation results for the associated analyte subset may be biased. Interferences from the sample matrix are typically responsible for internal standard responses that are consistently outside acceptable ranges; most matrix interferences cause a consistently high or low bias.

Internal standards were added to each of the project samples analyzed for VOCs. All of the internal standard responses were within acceptable limits, indicating minimal matrix interference and acceptable sample quantitation.

Surrogate Spikes

A surrogate spike is similar to an internal standard; it is chemically similar to the target analytes and is only used in organic analyses. The difference between surrogate spikes and internal standards is that surrogate spikes are used only to assess possible interferences from the sample matrix, whereas internal standards are used to quantitate target analytes while accounting for any interferences from the sample matrix. Surrogate spike results are typically reported in terms of percent recovery, which is calculated by dividing the amount of surrogate detected in the sample by the known amount of surrogate added to the sample.

For the February 1999 groundwater data, surrogate recoveries were compared to the laboratory-generated limits of acceptance. Three samples were qualified due to surrogate recoveries that were below method requirements (Table F.3-2). Detected compound results associated with the listed surrogate were qualified "J," estimated; non-detected compound results were qualified "UJ," estimated detection limit. The surrogate recoveries for the remaining samples were within acceptable limits, indicating that sample results were subject to minimal interferences from the sample matrix.

Duplicate Samples

A duplicate sample is a second aliquot of a sample that is treated the same as the primary sample. A duplicate sample analysis is performed to measure the precision of the method and possible heterogeneity of analyte concentrations in the sample matrix. Duplicate field samples are collected to measure matrix heterogeneity.

Laboratory duplicate analyses for the project samples consisted of matrix spike duplicate analyses. The laboratory calculated the relative percent difference (RPD) between the two detected values as applicable. The calculated RPDs were compared to method-prescribed or laboratory-generated acceptable limits. Two field duplicate samples also were collected and submitted for analysis (Table F.3-3).

The duplicate sample RPDs were within acceptable limits. The laboratory RPDs and field duplicate sample results indicate acceptable analytical accuracy and minimal matrix heterogeneity.

Overall Assessment

None of the Seattle ANGS Phase II RI analytical data for samples collected in February 1999 were rejected. The data set is 100 percent complete and meets the project goal for completeness. Unqualified data can be used for decision-making purposes. Qualified data also can be used for decision-

TABLE F.3-2

Surrogate Recovery Results Outside of Acceptable Limits
143rd CCSQ, Seattle ANGS, Seattle, Washington

Data Package	Sample ID	Analytical Method	Surrogate	% Recovery	Control Limit	ERM Qualifier*
902035	MW-4-99-1R	8260	1,2-Dichloroethane-d4	80	81-130	J/UJ
	MW-4-99-1	8260	1,2-Dichloroethane-d4	79	81-130	J/UJ
	MW-4-99-1D	8260	1,2-Dichloroethane-d4	78	81-130	J/UJ

R = Rinsate sample
D = Duplicate sample
J = Reported values for detected analytes associated with the listed surrogate are estimated concentrations.
UJ = Reported detection limits for analytes associated with the listed surrogate are estimated concentrations.
8260 = USEPA Method 8260 (volatile organic compounds)
*Data qualifiers apply to listed samples.

TABLE F.3-3

Field Duplicate Sample Results and Qualifiers
143rd CCSQ, Seattle ANGS, Seattle, Washington

Data Package	Primary Sample ID	Detected Analytes	Detection Limit (µg/L)	Primary Sample Concentration (µg/L)	Duplicate Sample Concentration (µg/L)	RPD	ERM Qualifier
902035	MW-8-99-1	cis-1,2-Dichloroethene	1	39	42	3.7	None
		Trichloroethene	1	83	87	2.4	None
	MW-4-99-1	Trichloroethene	1	2.6	2.6	0.0	None

RPD = Relative percent difference

making purposes; however, the limitations identified by the qualifiers should be considered when using the data. The quality of the February 1999 groundwater analytical data is acceptable for the preparation of technically defensible documents.

APPENDIX F.4

QUALITY CONTROL DATA VALIDATION REPORT - MAY 1999 GROUNDWATER DATA

Analytical data are the basis for evaluating the environmental conditions at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. A primary objective of environmental sampling conducted at the site is to obtain accurate data that reflect actual conditions.

This report addresses groundwater analytical data collected in May 1999 at the Seattle ANGS during the Phase II Remedial Investigation (RI). Eighteen groundwater samples were analyzed for volatile organic analytes using United States Environmental Protection Agency (USEPA) Method 8260. To ensure that data quality was acceptable for decision-making purposes, analytical data for this project were validated. This process identifies limitations on the use of the data, or data that should not be used for decision-making purposes. The quality of the data was assessed and any necessary qualifiers were applied following the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994).

Environmental Resources Management (ERM) validated data for compliance with the following quality assurance/quality control (QA/QC) project- and/or method-prescribed criteria:

- Holding Time: The period of time between collection of the sample and preparation/analysis of the sample. Analyses performed for this project have method-prescribed holding times.

- Calibration: The analysis of target analytes at a range of concentrations to develop a graphical plot of instrument response against the different analyte concentrations. An initial calibration curve establishes the graphical plot, and the continuing calibration verification monitors daily instrument linearity against the initial calibration.

- Blank Samples: The preparation and analysis of samples from reagent (contaminant-free) water. Blank samples for this investigation included method, trip, rinsate, and field blanks. Detections in a blank sample indicate laboratory, handling, or field contamination.

- Internal Standards: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. The internal standards are used to quantitatively and qualitatively evaluate retention time and instrument response for each analytical run.

- Spike Samples: The preparation and analysis of an environmental sample or a sample of reagent water spiked with a subset of target analytes at known concentrations. The results of the spike analysis measure laboratory accuracy in the reagent sample, and results from the environmental sample spike measure potential interferences from the sample matrix.

- Surrogate Spikes: The addition of compounds similar to target analytes of interest that are added to sample aliquots for organic analysis. Surrogate spikes measure possible interferences from the sample matrix for the analysis of target analytes.

- Duplicate Samples: The preparation and analysis of an additional aliquot of the sample. The results from duplicate analysis measure potential heterogeneity of contaminant concentrations in the samples.

The following data qualifiers were used as appropriate during this validation process:

U: The analyte was analyzed for, but was not detected above the reported quantitation limit.

J: The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

N: The analysis indicated the presence of an analyte for which there was presumptive evidence to make a "tentative identification."

NJ: The analysis indicated the presence of an analyte that was "tentatively identified" and the associated numerical value represents its approximate concentration.

UJ: The analyte was not detected above the reported sample quantitation limit; however, the reported quantitation limit was

approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R: The sample results were rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte could not be verified.

None of the May 1999 groundwater data were rejected based on the data validation. All of the data, including data flagged as having estimated values, are acceptable and can be used for decision-making purposes.

The following discussion addresses the results of the data validation for each of the QA/QC components listed above.

Holding Time

The USEPA has established maximum recommended holding times for the analyses performed on the Phase II RI groundwater samples. Holding times extending beyond the maximum can negatively affect sample integrity (e.g., loss of volatile compounds, biodegradation), and impacted samples are qualified depending on the severity of the exceedence and the analytes of concern. The maximum holding time for USEPA Method 8260 is 14 days from the date of collection for preserved samples and 7 days from date of collection for unpreserved samples. Each of the sample analysis results was reviewed for compliance with the method-prescribed preparation and analysis holding times. None of the reported analyses were performed outside of the prescribed holding time. Accordingly, sample results were not compromised by an excessive period between sample collection and analysis.

Calibration Results

Before an analytical instrument is used for sample analysis, the instrument should be calibrated to within USEPA method specifications. The purpose of this calibration is to ensure that the instrument is appropriately responsive to measurable chemical concentrations. If an instrument is not properly calibrated, it may not be capable of producing acceptable quantitative, qualitative, and reproducible data. For example, positive detections of a given analyte could contain an undetermined degree of inaccuracy if the instrument is out of calibration, although the results may still be considered valid. In the case of non-detected (ND) analytes, the associated reporting limit would be similarly affected; however, such results would still be considered NDs.

Two types of calibration data were reviewed: initial calibration verification (ICV) and continuing calibration verification (CCV). The ICV consisted of standards that were analyzed at five or more concentrations. These concentrations ranged from the reporting limit to the upper linear range of the instrument. Average response factors from the ICV were used to calculate sample results. The laboratory evaluated the ICVs using relative standard deviation (RSD). The reported RSDs were compared to the method-prescribed acceptance criteria during the data validation. Any data associated with an ICV that had target analytes with an RSD above the acceptable method-prescribed criteria were qualified either "J," estimated, for detected analytes, or "UJ," estimated detection limit, for ND analytes.

The CCV is analyzed either daily or every 12 hours to ensure the instrument response is still within method performance criteria for linearity. The CCV consisted of analyzing a standard at one concentration; the concentration of this standard was generally in the mid-range of the ICV standard concentrations. The laboratory calculated the percent difference (%D) between CCV and the ICV. The %Ds were compared to the method-prescribed acceptance criteria during the data validation. Any data associated with a CCV that had target analytes with a %D above the method-prescribed criteria were qualified either "J," estimated, for detected analytes, or "UJ," estimated detection limit, for ND analytes.

The results for the target compounds and project samples listed on Table F.4-1 were qualified "UJ," estimated detction limit, based on an elevated RSD or %D. None of the other data required qualification based on ICV or CCV results.

Blank Samples

Blank samples are prepared in the laboratory or in the field and are carried through the analytical process. The purpose of a blank sample is to test for contamination resulting from laboratory, shipping, or other sample-handling activities. Blank samples are analyzed and evaluated for detections of target analytes. If target analytes are detected in a blank sample, these detections indicate that some element of the sample collection or analysis process has introduced contaminants not present in the original environmental sample aliquot. If target analytes are detected

TABLE F.4-1
Data Qualified Based on Calibration Results
143rd CCSQ, Seattle ANGS, Seattle, Washington

Data Package	Analytical Parameter	Calibration (ICV/CCV)	Date	Associated Samples	Target Compound	RSD or %D	ERM Qualifier*
905045	VOCs	ICV	5/25/99	MW-8-99-2FT	Bromomethane	19.9	UJ
				MW-8-99-2FA	1,2-Dichloroethane	16.2	UJ
				MW-8-99-2	1,1,2-Trichloroethane	19.8	UJ
				MW-8-99-2D	Chlorodibromomethane	19.6	UJ
				MW-6-99-2	Bromoform	26.5	UJ
				MW-7-99-2			
				TB051899-1			
				MW-4-99-2			
				MW-4-99-2R			
				MW-5-99-2			
				MW-3-99-2			
				BS-005PZ-99-2			
				BS-006PZ-99-2			
				MW-2-99-2			
				MW-9-99-2			
				BS-004PZ-99-2			
				MW-10-99-2			
				MW-1-99-2			
		CCV	5/26/99	MW-8-99-2D	Bromoform	32.8	UJ
				MW-7-99-2			
				TB051899-1			
				MW-4-99-2			
				MW-4-99-2R			
				MW-5-99-2			
				MW-3-99-2			
				BS-005PZ-99-2			
				BS-006PZ-99-2			
				MW-2-99-2			
				MW-9-99-2			
				BS-004PZ-99-2			
				MW-10-99-2			
				MW-1-99-2			

ICV= Initial calibration verification
CCV= Continuing calibration verification
RSD = Relative standard deviation
%D = Percent difference
VOCs = Volatile organic compounds
D = Duplicate sample
FA = Field blank prepared using ASTM Type II water
FT = Field blank prepared using tap water
UJ = Reported detection limits for the listed compounds and samples are estimated concentrations.
* Data qualifiers applied to affected sample data points indicated.

in a blank sample, then all associated data must be evaluated to determine whether:

- Those data have been similarly impacted; or
- The blank detections are an isolated occurrence not representative of other data.

The four types of blank samples analyzed and reported with the groundwater samples collected in May 1999 were method, trip, rinsate, and field blank samples. Preparation, handling, and analysis of these blank samples are summarized below.

1. Method blank samples monitor for potential laboratory contamination of samples. Method blank samples were prepared in the laboratory by taking an aliquot of reagent water through all preparation and analysis steps. A method blank was prepared and analyzed with each batch of environmental samples.

2. Trip blank samples monitor for potential contamination of samples during collection and transportation to the laboratory. Trip blank samples were prepared by filling a volatile organics analysis (VOA) vial with an aliquot of reagent water and sealing it with a Teflon-lined-septum lid. The trip blank sample travels with the filled aqueous sample containers to the laboratory.

3. Rinsate blank samples monitor for potential contamination of project samples from inadequate decontamination of sample collection equipment. Rinsate blank samples were prepared in the field by pouring American Society for Testing and Materials (ASTM) Type II reagent-grade water over the decontaminated sample collection equipment. The water was collected in clean sample containers supplied by the laboratory. Rinsate blank samples were labeled with an "R" identifier at the end of the sample ID.

4. Field blank samples monitor for potential contamination of project samples from ambient conditions at the sample collection site. Field blank samples were prepared at sample collection locations by slowly pouring tap water or ASTM Type II water into clean sample containers supplied by the laboratory. Field blank samples prepared with tap water were labeled with an "FT" identifier at the end of the sample ID. The identifier "FA" was used to designate field blank samples prepared with ASTM Type II water.

No target analytes were detected in any of the method blank samples. The common drinking water contaminants chloroform and bromodichloromethane were detected in sample MW-8-99-2FT, the field blank prepared with tap water. The common laboratory contaminant acetone was detected in sample MW-8-99-2FA, the field blank prepared with ASTM Type II water, and in the rinsate blank, MW-4-99-2R. Acetone was not detected in the associated project samples. None of the data required qualification based on the blank results.

Spike Samples

A spike sample is a QC sample that is prepared and analyzed by the laboratory. The laboratory prepares, analyzes, and reports spike sample results to demonstrate their ability to properly analyze, detect, and quantify target analytes. A spike sample result is typically reported as the amount of analyte detected divided by the known amount spiked into the sample, and is commonly referred to as percent recovery. The percent recovery is then compared to an established limit range.[1] The two types of spike samples analyzed with the project samples were matrix and blank spikes.

1. Matrix spike (MS) samples consist of an aliquot of an environmental sample that is spiked with known concentrations of a subset of target analytes. A matrix spike duplicate (MSD) sample is a second (duplicate) spike sample prepared and analyzed with the MS sample. MS samples are used to monitor potential interference from the sample matrix for target analytes. A low MS recovery may indicate low-biased sample results; a high MS recovery may indicate high-biased sample results.

2. Blank spike samples, commonly referred to as laboratory control samples (LCS), consist of an aliquot of reagent water that is spiked with known concentrations of a subset of target analytes. The LCS sample is used to monitor laboratory accuracy without the bias of a sample matrix. LCS recoveries outside of acceptable limits may indicate poor laboratory accuracy.

All of the MS and LCS and MS recoveries were within acceptable limits. The acceptable MS and LCS recoveries indicate minimal matrix

[1] In most cases, the prescribed analytical method will specify protocol to develop appropriate limit ranges. In some cases, however, limit ranges are established by the laboratory in the method procedures.

interference and acceptable laboratory accuracy for the May 1999 groundwater data.

Internal Standard Responses

Under USEPA methods, a given analyte list for organic compounds is segregated by chemical properties and retention time into one or more subsets. A USEPA-defined internal standard with comparable chemical properties and retention times is assigned to each subset of analytes. The laboratory adds a known concentration of an internal standard to each sample, including laboratory QC samples (e.g., calibration standards, MS, method blank samples), prior to analysis. The instrument internal standard response for each sample is compared to the internal standard response in the daily CCV. The sample internal standard area count must be within the range of 0.5 to 2 times the CCV area count, and the retention time must be within ±30 seconds of the CCV retention time. If the area count and/or retention time measured for the sample is outside the acceptable range, quantitation results for the associated analyte subset may be biased. Interferences from the sample matrix are typically responsible for internal standard responses that are consistently outside acceptable ranges; most matrix interferences cause a consistently high or low bias.

Internal standards were added to each of the project samples analyzed for VOCs. All of the internal standard responses were within acceptable limits, indicating minimal matrix interference and acceptable sample quantitation.

Surrogate Spikes

A surrogate spike is similar to an internal standard; it is chemically similar to the target analytes and is only used in organic analyses. The difference between surrogate spikes and internal standards is that surrogate spikes are used only to assess possible interferences from the sample matrix, whereas internal standards are used to quantitate target analytes while accounting for any interferences from the sample matrix. Surrogate spike results are typically reported in terms of percent recovery, which is calculated by dividing the amount of surrogate detected in the sample by the known amount of surrogate added to the sample.

For the May 1999 groundwater data, surrogate recoveries were compared to the laboratory-generated limits of acceptance. The surrogate recoveries were within acceptable limits, indicating that sample results were subject to minimal interferences from the sample matrix.

Duplicate Samples

A duplicate sample is a second aliquot of a sample that is treated the same as the primary sample. A duplicate sample analysis is performed to measure the precision of the method and possible heterogeneity of analyte concentrations in the sample matrix. Duplicate field samples are collected to measure matrix heterogeneity.

Laboratory duplicate analyses for the project samples consisted of matrix spike duplicate analyses. The laboratory calculated the relative percent difference (RPD) between the two detected values as applicable. The calculated RPDs were compared to method-prescribed or laboratory-generated acceptable limits. One field duplicate sample also was collected and submitted for analysis.

The duplicate sample RPDs were within acceptable limits. The laboratory RPDs and field duplicate sample results indicate acceptable analytical accuracy and minimal matrix heterogeneity.

Overall Assessment

None of the Seattle ANGS Phase II RI analytical data for samples collected in May 1999 were rejected. The data set is 100 percent complete and meets the project goal for completeness. Unqualified data can be used for decision-making purposes. Qualified data also can be used for decision-making purposes; however, the limitations identified by the qualifiers should be considered when using the data. The quality of the May 1999 groundwater analytical data is acceptable for the preparation of technically defensible documents.

APPENDIX G

CHAIN-OF-CUSTODY RECORDS

TRANSGLOBAL ENVIRONMENTAL GEOSCIENCES

CHAIN-OF-CUSTODY RECORD

CLIENT: Environmental Resources Management

ADDRESS: 915 118th Ave SE

PHONE (425) 462-8591 FAX:

CLIENT PROJECT #: 6051.31 PROJECT MANAGER: Rob Leet

DATE: 7/28/98 PAGE 1 OF 2

PROJECT NAME: PSH Sang Phase II RI

LOCATION: Seattle

COLLECTOR: STM

DATE OF COLLECTION

Sample Number	Depth	Time	Sample Type	Container Type	VOA 601/8010	VOA 602/8020	VOA 624/8240	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH (8015 (diesel)	TPH 8015 (g & d)	PAH 610/8100	PEST/PCBs 8080	HEX CHROME	ORGANIC LEAD	TOTAL LEAD	pH	ASBESTOS	8021B	FIELD NOTES	Total Number of Containers	Laboratory Note Number
SVS-1	5'	0945	SV	VACUUM																/		2	
SVS-2	5'	1005	SV	VACUUM																/		2	
SVS-4	5'	1020	SV	VACUUM																/		2	
SVS-3	5'	1045	SV	VACUUM																/		2	
SVS-5	5'	1120	SV	VACUUM																/		2	
SVS-5R	5'	1120	EN	~~VACUUM~~ VOA																/		~~2~~ 3	
SVS-5D	5'	1120	SV	VACUUM																/		2	
SVS-6	5'	1155	SV	VACUUM																/		2	
SVS-7	5'	1245	SV	VACUUM																/		2	
SVS-8	5'	1309	SV	VACUUM																/		2	
SVS-9	5'	1330	SV	VACUUM																/		2	
SVS-9AA	5'	1330	SV	VACUUM																/		2	
SVS-9EB	5'	1330	SV	VACUUM																/		2	
SVS-10	5'	1400	SV	VACUUM																/		2	
SVS-11	5'	1421	SV	VACUUM																/		2	
SVS-12	5'	1443	SV	VACUUM																/		2	
SVS-13	5'	1510	SV	VACUUM																/		2	
SVS-14	5'	1530	SV	VACUUM																/		2	

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SAMPLE DISPOSAL INSTRUCTIONS

☐ TEG DISPOSAL @ $2.00 each ☐ Return ☐ Pickup

SAMPLE RECEIPT	
TOTAL NUMBER OF CONTAINERS	
CHAIN OF CUSTODY SEALS Y/N/NA	
SEALS INTACT? Y/N/NA	
RECEIVED GOOD COND./COLD	
NOTES:	

LABORATORY NOTES:
R= Rinsate
D= Duplicate
AA= Ambient Air
EB= Equip. Blank

KCSlip4 41480

SEA408010

teg TRANSGLOBAL ENVIRONMENTAL GEOSCIENCES

CHAIN-OF-CUSTODY RECORD

CLIENT: ERM
ADDRESS: 915 118TH AVE SE
PHONE (425) 462-8591 FAX:
CLIENT PROJECT #: 6051.31 PROJECT MANAGER: ROB LEET

DATE: 7/28/98 PAGE 2 OF 2
PROJECT NAME: ANGS PHASE II RI
LOCATION: SEATTLE
COLLECTOR: STM DATE OF COLLECTION

Sample Number	Depth	Time	Sample Type	Container Type	VOA 601/8010	VOA 602/8020	VOA 624/8240	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH (8015 (diesel)	TPH 8015 (g & d)	PAH 610/8100	PEST/PCBs 8080	HEX CHROME	ORGANIC LEAD	TOTAL LEAD	pH	ASBESTOS	8021B	FIELD NOTES	Total Number of Containers	Laboratory Note Number
SVS-15R	5'	1600	W	VOA																/		3 ~~2~~ SM	
SVS-15FT	5'	1600	W	VOA																/		3 ~~2~~ SM	
SVS-15FA	5'	1600	W	VOA																/		3 ~~2~~ SM	
SVS-15D	5'	1600	SV	Vacuum																/		2	
~~SVS-35D~~	~~5'~~	~~1424~~	~~SV~~	~~Vacuum~~																/			SM
TB072898-1			W	VOA																/		2	
Total																						9	SM

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RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME

SAMPLE DISPOSAL INSTRUCTIONS
☐ TEG DISPOSAL @ $2.00 each ☐ Return ☐ Pickup

SAMPLE RECEIPT	
TOTAL NUMBER OF CONTAINERS	
CHAIN OF CUSTODY SEALS Y/N/NA	
SEALS INTACT? Y/N/NA	
RECEIVED GOOD COND./COLD	
NOTES:	

LABORATORY NOTES:
R = RINSATE
FT = Field Blank TAP
FA = Field Blank ASTM

KCSlip4 41481

SEA408011

TRANSGLOBAL ENVIRONMENTAL GEOSCIENCES

CHAIN-OF-CUSTODY RECORD

CLIENT: ERM

ADDRESS: 915 TH & 118TH AVE SE

PHONE (425) 462-8591 FAX:

CLIENT PROJECT #: 6051.31 PROJECT MANAGER: Rob Lint

DATE: 7/29/98 PAGE 1 OF 2

PROJECT NAME: ANGS Phase II RI

LOCATION: Seattle, WA

COLLECTOR: Scott Miyamoto DATE OF COLLECTION 7/29/98

Sample Number	Depth	Time	Sample Type	Container Type	VOA 601/8010	VOA 602/8020	VOA 624/8240	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH (8015 (diesel)	TPH 8015 (g & d)	PAH 610/8100	PEST/PCBs 8080	HEX CHROME	ORGANIC LEAD	TOTAL LEAD	pH	ASBESTOS	8021B					FIELD NOTES	Total Number of Containers	Laboratory Note Number
SVS-16	5'	0730	SV	VACUUM																X						2	
SVS-17	5'	0800	SV	VACUUM																X						2	
SVS-18	5'	0820	SV	VACUUM																X						2	
SVS-19	5'	0837	SV	VACUUM																X						2	
SVS-20	5'	0850	SV	VACUUM																X						2	
SVS-21	5'	0910	SV	VACUUM																X						2	
~~A~~ SVS-22	5'	[illegible]	SV	VACUUM																X						2	
SVS-23	5'	0940	SV	VACUUM																X						2	
SVS-24	5'	1010	SV	VACUUM																X						2	
SVS-26	5'	1050	SV	VACUUM																X						2	
SVS-27	5'	1105	SV	VACUUM																X						2	
SVS-28	5'	1120	SV	VACUUM																X						2	
SVS-29	5'	1135	SV	VACUUM																X						2	
SVS-30	5'	1155	SV	VACUUM																X						2	
SVS-31	5'	1220	SV	VACUUM																X						2	
SVS-32	5'	1320	SV	VACUUM																X						2	
SVS-33	5'	1340	SV	VACUUM																X						2	
SVS-34	5'	1350	SV	VACUUM																X						2	

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[signature]	7/29/98 1614	[signature]	7/29/98
RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME

SAMPLE RECEIPT	
TOTAL NUMBER OF CONTAINERS	
CHAIN OF CUSTODY SEALS Y/N/NA	
SEALS INTACT? Y/N/NA	
RECEIVED GOOD COND./COLD	
NOTES:	

LABORATORY NOTES:
R = RINSATE
FT = Field Blank (TAP)
FA = Field Blank (ASTM)
D = DUPLICATE

SAMPLE DISPOSAL INSTRUCTIONS

☐ TEG DISPOSAL @ $2.00 each ☐ Return ☐ Pickup

KCSlip4 41482

SEA408012

teg TRANSGLOBAL ENVIRONMENTAL GEOSCIENCES

CHAIN-OF-CUSTODY RECORD

CLIENT: ERM

ADDRESS: 915 1st A 118TH AVE SE

PHONE (425) 462-8591 FAX:

CLIENT PROJECT #: 6051.31 PROJECT MANAGER: Rob Leer

DATE: 7/29/98 PAGE 2 OF 2

PROJECT NAME: Angs PHASE II RI

LOCATION: SEATTLE, WA

COLLECTOR: Scott Mikimoto DATE OF COLLECTION 7/29/98

Sample Number	Depth	Time	Sample Type	Container Type	VOA 601/8010	VOA 602/8020	VOA 624/8240	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH (8015 (diesel)	TPH 8015 (g & d)	PAH 610/8100	PEST/PCBs 8080	HEX CHROME	ORGANIC LEAD	TOTAL LEAD	pH	ASBESTOS	8021B	FIELD NOTES	Total Number of Containers	Laboratory Note Number
SVS-35	5'	1424	SV	VACUUM																X		2	
SVS-35ED	5'	1424	SV	VACUUM																X		2	
SVS-36	5'	1445	SV	VACUUM																X		2	
SVS-37	5'	1524	SV	VACUUM																X		2	
SVS-25	5'	1510	SV	VACUUM																X		2	
SVS-25D	5'	1510	SV	VACUUM																X		2	
SVS-38	5'	1540	SV	VACUUM																X		2	
SVS-39	5'	1552	SV	VACUUM																X		2	
SVS-40	5'	1605	SV	VACUUM																X		2	
~~SVS-35M~~	5'	~~1424~~	~~SV~~	~~VACUUM~~																X		2	
SVS-25R	5'	1510	W	VOA																X		3	
SVS-35R	5'	~~15..~~ 1424	W	VOA																X		3	
~~SVS~~-35D	5'	1424	SV	VACUUM																X		2	
TB072998-1	~~5'~~		W	VOA																X		2	

RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME
Scott Mikimoto	7/29 @ 1648	Michael G. R...	7/29/98
RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME

SAMPLE DISPOSAL INSTRUCTIONS

☐ TEG DISPOSAL @ $2.00 each ☐ Return ☐ Pickup

SAMPLE RECEIPT	
TOTAL NUMBER OF CONTAINERS	
CHAIN OF CUSTODY SEALS Y/N/NA	
SEALS INTACT? Y/N/NA	
RECEIVED GOOD COND./COLD	
NOTES:	

LABORATORY NOTES:
R = RINSATE
AA = AMBIENT AIR
EB = EQUIPMENT BLANK

KCSlip4 41483

SEA408013

ERM.

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

DATE 8/12/98 PAGE 1 OF 2

PROJECT NAME Sample ANGS # 6051.31

PROJECT MANAGER Rob Leet

COMPANY/ADDRESS 915 118th AVE NE
Bellvue, WA

FAX (425) 455-3573 PHONE (425) 462-8591

SAMPLERS SIGNATURE

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX	NUMBER OF CONTAINERS	Base/Neu/Acid Organics GC/MS 625/8270	Volatile Organics GC/MS 624/8240	Halogenated or Aromatic Volatiles 601/8010☐ 602/8020☐	Pesticides/PCBs 608/8080	Total Petroleum Hydrocarbons EPA/418.1☐ OR/418.1☐ WA/418.1☐	TPH/Gas/BTEX Gas☐ BTEX ~~8020/8015/8020~~ 8021B	TPH/8015 Modified Diesel☐ Hydrocarbon Scan☐	TPH/HCID☐ OR/HCID☐ WA/HCID☐	TCLP Metals☐ VOA☐ Semi VOA☐ Pest/ Herb☐	Metals (total or dissolved) List Below	Cyanide	pH, Cond, Cl, SO_4, PO_4, F, Br NO_2, NO_3, (circle)	NH_3-N, COD, Total-P, TKN, TOC (circle)	Total Organic Halides (TOX) 9020☐ (AOX) 1650A☐			REMARKS
GP-36	8/12/98	1330		W	2						/											
GP-36D	8/12/98	1330		W	2						/											
GP-~~37~~35	8/12/98	1425		W	~~2~~	4ct					/											
GP-34	8/12/98	1500		W	2						/											
GP-39	8/12/98	0845		W	2						/											
GP-40	8/12/98	0935		W	2						/											
GP-41	8/12/98	1010		W	2						/											
GP-~~08~~42	8/12/98	1100		W	2						/											
GP-38	8/12/98	1130		W	2						/											
37 GP-~~37~~35	8/12/98	1220		W	~~2~~	x2					/											

RELINQUISHED BY:	RECEIVED BY:	TURNAROUND REQUIREMENTS	REPORT REQUIREMENTS	INVOICE INFORMATION:	SAMPLE RECEIPT:
Signature	Signature	___ 24 hr ___ 48 hr. ___ 5 day	___ I. Routine Report	P.O.#	Shipping VIA:
Printed Name	Printed Name	___ Standard (10-15 working days)	___ II. Report (includes DUP,MS, MSD, as required, may be charged as samples)	Bill To	Shipping #:
Firm	Firm	___ Provide Verbal Preliminary Results	___ III. Data Validation Report (includes All Raw Data)		Condition:
Date/Time	Date/Time	___ Provide FAX preliminary Results	___ IV. CLP Deliverable Report		Lab No:
		Requested Report Date ___			

RELINQUISHED BY:	RECEIVED BY:	SPECIAL INSTRUCTIONS/COMMENTS:
Signature	Signature	Rob Leet called 8/17 : change GP-08 to GP-42 on chain & printout
Printed Name	Printed Name	
Firm	Firm	
Date/Time	Date/Time	

DISTRIBUTION: WHITE - return to originator; YELLOW - lab; PINK - retained by originator

400-05

KCSlip4 41484

SEA408014

ERM

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

DATE 8/12/98 PAGE 2 OF 2

PROJECT NAME Seattle ANGS # 6051.31

PROJECT MANAGER ROB LEET

COMPANY/ADDRESS 915 118TH AVE SE
Bellevue, WA 98005

FAX (425) 455-3573 PHONE (425) 462-8591

SAMPLERS SIGNATURE [signature]

ANALYSIS REQUESTED

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX	NUMBER OF CONTAINERS	Base/Neu/Acid Organics GC/MS 625/8270	Volatile Organics GC/MS 624/8240	Halogenated or Aromatic Volatiles 601/8010 ☐ 602/8020 ☐	Pesticides/PCBs 608/8080	Total Petroleum Hydrocarbons EPA/418.1 ☐ OR/418.1 ☐ WA/418.1 ☐	~~TPH/Gas/BTEX 5030/8015/8020~~ 8021B ~~Gas ☐ BTEX ☐~~	TPH/8015 Modified Diesel ☐ Hydrocarbon Scan ☐	TPH/HCID ☐ OR/HCID ☐ WA/HCID ☐	TCLP Metals ☐ VOA ☐ Semi VOA ☐ Pest/Herb ☐	Metals (total or dissolved) List Below	Cyanide	pH, Cond, Cl, SO_4, PO_4, F, Br NO_2, NO_3 (circle)	NH_3-N, COD, Total-P, TKN, TOC (circle)	Total Organic Halides (TOX) 9020 ☐ (AOX) 1650A ☐			REMARKS
GP-33	8/12/98	1595		W	2						✓											
TB081298-1	8/12/98			W	1						✓											

RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS
___ 24 hr ___ 48 hr. ___ 5 day
___ Standard (10-15 working days)
___ Provide Verbal Preliminary Results
___ Provide FAX preliminary Results
Requested Report Date ___

REPORT REQUIREMENTS
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Data Validation Report (includes All Raw Data)
___ IV. CLP Deliverable Report

INVOICE INFORMATION:
P.O.#
Bill To

SAMPLE RECEIPT:
Shipping VIA:
Shipping #:
Condition:
Lab No:

RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

SPECIAL INSTRUCTIONS/COMMENTS:

KCSlip4 41485

SEA408015

MultiChem ANALYTICAL SERVICES

560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 • (425) 228-8335 • FAX (425) 228-8336

LAB NUMBER: 9808031

DATE: 8/12/98
PAGE: 1 of 1

COMPANY: ERM-WEST
ADDRESS: 915 118th AVE SE
BELLEVUE, WA 98005
PHONE: (425) 462-8591 FAX (425) 455-3573
PROJ. MGR / CONTACT: BOB LEET
PROJECT NUMBER: 6051.31
PROJECT NAME: Phase II RI Scrap Area
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

Analyses: FUELS: TPH-HCID; BETX / TPH-G BETX / AK101; BETX (by 8021); TPH-G; TPH-D TPHD-extended; 8015 modified; 418.1; 413.2; AK-GRO AK101; AK-DRO AK102 / 103. ORGANIC COMPOUNDS: 8240 / 8260 GCMS Volatiles; 8270 GCMS Semivolatiles; 8081 Pesticides / PCBs; PCB only (by 8081) SID / LL; 8021 Halogenated VOCs; 8021 Aromatic VOCs; 8310 HPLC PAHs; 8041 Phenols; 8151 OC Herbicides. METALS: Metals indicate below*; Total / Dissolved Lead; RCRA Metals (8); PP Metals (13); TAL Metals (23). TCLP: TCLP 8240 (ZHE); TCLP 8270 Semivolatiles; TCLP 8081 Pesticides; TCLP 8151 Herbicides; TCLP Metals. OTHER. Total # of Containers.

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	8240 / 8260 GCMS Volatiles
GP-37-7.0	8/12/98	0845	S		/
GP-40-6.0	8/12/98	0915	S		/
GP-41-7.0	8/12/98	1000	S		/
GP-42-6.0 (RCL)	8/12/98	1050	S		/
GP-37-6.0 → Jar said GP-37-6.0, should be GP-38-6.0	8/12/98	1125	S		/
GP-37-7.0	8/12/98	1215	S		/
GP-36-7.0	8/12/98	1315	S		/
GP-36-7.0	8/12/98	1215	S		/
GP-33-7.0 (RCL)	8/12/98	1415	S		/
GP-34-7.0	8/12/98	1495	S		/
GP-33-8.0	8/12/98	1540	S		/

SAMPLE RECEIPT

TOTAL # OF CONTAINERS	☐ YES	☐ NO
COC SEALS PRESENT?	☐ YES	☐ NO
COC SEALS INTACT?	☐ YES	☐ NO
RECEIVED COLD?	☐ YES	☐ NO
RECEIVED INTACT?	☐ YES	☐ NO
RECEIVED VIA:		

TAT: ☐ 24 HOURS ☐ 48 HOURS ☐ 72 HOURS ☐ 7 DAYS ☐ SP ☐ STANDARD

RELINQUISHED BY:	RELINQUISHED BY:	RELINQUISHED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Scott Murano	PRINT NAME:	PRINT NAME:
DATE: 8/14/98 TIME: 0800	DATE: TIME:	DATE: TIME:
COMPANY: ERM	COMPANY:	COMPANY:

RECEIVED BY:	RECEIVED BY:	RECEIVED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: [illegible]	PRINT NAME:	PRINT NAME:
DATE: 8/14/[illegible] TIME: [illegible]	DATE: TIME:	DATE: TIME:
COMPANY: [illegible]	COMPANY:	COMPANY:

MAS USE ONLY: SUBCONTRACTED LAB

SPECIAL INSTRUCTIONS/COMMENTS:
call lab

*METALS NEEDED:

KCSlip4 41486
SEA408016

teg TRANSGLOBAL ENVIRONMENTAL GEOSCIENCES

CHAIN-OF-CUSTODY RECORD

CLIENT: ~~Seattle Angs~~ ERM-WEST

ADDRESS: 915 118TH AVE SE

PHONE (425) 462-8591 FAX: (425) 455-3573

CLIENT PROJECT #: Seattle Angs PROJECT MANAGER: Robert

DATE: 8/13/98 PAGE 1 OF

PROJECT NAME: Seattle Angs

LOCATION: Seattle, WA

COLLECTOR: STM / DEW DATE OF COLLECTION 8/13/98

Sample Number	Depth	Time	Sample Type	Container Type	VOA 601/8010	VOA 602/8020 8021B	VOA 624/8240	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH (8015 (diesel)	TPH 8015 (g & d)	PAH 610/8100	PEST/PCBs 8080	HEX CHROME	ORGANIC LEAD	TOTAL LEAD	pH	ASBESTOS	TPH-HCID	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GP-28		0745	W			✓																2	
GP-27		0830	W			✓																2	
GP-26		[illegible]	W			✓																2	
GP-26D		0905	W			✓																2	
GP-25		0945	W			✓																2	
GP24		1020	W			✓																2	
GP23 ~~8.0~~		1040	W			✓																2	
GP32		1130	W			✓																2	
GP30		1145	W			✓																2	
GP-31		1225	W			✓																2	
GP-29		1255	W			✓																2	
TB081398-1		—	W			✓																2	

RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME
[signature]	8/13/98 @ 1420	[signature]	[illegible]
RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME

SAMPLE RECEIPT	
TOTAL NUMBER OF CONTAINERS	24
CHAIN OF CUSTODY SEALS Y/N/NA	
SEALS INTACT? Y/N/NA	
RECEIVED GOOD COND./COLD	Yes
NOTES:	

LABORATORY NOTES:

SAMPLE DISPOSAL INSTRUCTIONS

☐ TEG DISPOSAL @ $2.00 each ☐ Return ☐ Pickup

KCSlip4 41487

SEA408017

ERM

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

808051

DATE 8/13/98 PAGE 1 OF 2

PROJECT NAME Seattle ANGS # 605131

PROJECT MANAGER Rob Leet

COMPANY/ADDRESS 915 118th AVE SE
Bellevue, WA 98005

FAX (425) 455-3573 PHONE (425) 462-8591

SAMPLERS SIGNATURE Don Wyll

2-liter date pkg

ANALYSIS REQUESTED

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX	NUMBER OF CONTAINERS	Base/Neu/Acid Organics GC/MS 625/8270	Volatile Organics GC/MS ~~624/8240~~ 8260	Halogenated or Aromatic Volatiles 601/8010 ☐ 602/8020 ☐	Pesticides/PCBs 608/8080	Total Petroleum Hydrocarbons EPA/418.1 ☐ OR/418.1 ☐ WA/418.1 ☐	TPH/Gas ☐ BTEX ☐	TPH/8015 Modified Diesel ☐ Hydrocarbon Scan ☐	TPH/HCID ☐ OR/HCID ☐ WA/HCID ☐	TCLP Metals ☐ VOA ☐ Semi ☐ Pest ☐ Herb ☐	Metals (total or dissolved) List Below	Cyanide	pH, Cond, Cl, SO_4, PO_4, F, Br, NO_2, NO_3 (circle)	NH_3-N, COD, Total-P, TKN, TOC (circle)	Total Organic Halides (TOX) 9020 ☐ (AOX)	8260 (RL)	TPH-HCID	REMARKS
GP-28-8.0	8/13/98	0740	1	~~W~~ S	1		/															
GP-27-8.0	8/13/98	0815	2	S	1		/															
GP-26-8.0	8/13/98	0855	3	S	1		/															
GP-26R	8/13/98	0900	4	W	2		/	SM											/			
~~GP24~~	8/13/98			W	2		/															
GP24R	8/13/98	0955	5	W	2		/													X		call lab - can they test for, using VOAs?
GP24[illegible]	8/13/98	1000	6	W	2		/	SM												X		
GP24 [illegible]	8/13/98	0950	7	W	2		/	SM												X		
GP25D	8/13/98	0940	8	S	1														/	/		
GP25-8.0	8/13/98	0940	9	S	1														/	/		

RELINQUISHED BY:
Signature: [signature] 725
Printed Name: [illegible]
Firm: ERM
Date/Time: 8/13/98 @ 1510

RECEIVED BY:
Signature: Elaine Walker
Printed Name: Elaine Walker
Firm: MultiChem
Date/Time: 8/13/98 1510

TURNAROUND REQUIREMENTS
___ 24 hr ___ 48 hr. ___ 5 day
___ Standard (10-15 working days)
___ Provide Verbal Preliminary Results
___ Provide FAX preliminary Results
Requested Report Date ___

REPORT REQUIREMENTS
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Data Validation Report (includes All Raw Data)
___ IV. CLP Deliverable Report

INVOICE INFORMATION:
P.O.# ___
Bill To ___

SAMPLE RECEIPT:
Shipping VIA: ___
Shipping #: ___
Condition: ___
Lab No: ___

RELINQUISHED BY:
GP25D ⇒ should be GP-25-8.0D
(dup of GP-25-8.0)
Signature
Printed Name
Firm
Date/Time

RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

SPECIAL INSTRUCTIONS/COMMENTS:

DISTRIBUTION: WHITE - return to originator; YELLOW - lab; PINK - retained by originator

400-05

KCSlip4 41488

SEA408018

ERM.

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

808031

DATE 8/13/98 PAGE 2 OF 2

PROJECT NAME Seale Air # 6051.31

PROJECT MANAGER Rob Leet

COMPANY/ADDRESS 915 118th AVE SE Bellevue, WA

FAX (425)455-3573 PHONE (425)462-8591

SAMPLERS SIGNATURE [signature] [signature]

call lab

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX	NUMBER OF CONTAINERS	Base/Neu/Acid Organics GC/MS 625/8270	Volatile Organics GC/MS 624/8240 8260	Halogenated or Aromatic Volatiles 601/8010 ☐ 602/8020 ☐	Pesticides/PCBs 608/8080	Total Petroleum Hydrocarbons EPA/418.1 ☐ OR/418.1 ☐ WA/418.1 ☐	TPH/Gas/BTEX 5030/8015/8020 Gas ☐ BTEX ☐	TPH/8015 Modified Diesel ☐ Hydrocarbon Scan ☐	TPH/HCID ☐ OR/HCID ☐ WA/HCID ☐	TCLP Metals ☐ VOA ☐ Semi VOA ☐ Pest/Herb ☐	Metals (total or dissolved) List Below	Cyanide	pH, Cond, Cl, SO4, PO4, F, Br NO2, NO3, (circle)	NH3-N, COD, Total-P, TKN, TOC (circle)	Total Organic Halides (TOX) 9020 ☐ (AOX) 1650 ☐	TPH-HCID	8021B 8260	REMARKS
GP-24-8.0	8/13/98	1010	10	S	2		✓													✓		MS/MSD
GP-23-8.0	8/13/98	~~1040~~ 1050	11	S	2		✓													✓		RCL
GP32-7.0	8/13/98	1110	12	S	1		✓															
GP30-8.0	8/13/98	1145	13	S	1		✓															
GP-31-7.5	8/13/98	1220	14	S	1		✓															
GP-27-7.0	8/13/98	1245	15	S	1		✓															
GP-36R	8/12/98	1405	16	W	2																✓	
TB081298	8/12/98		17	W	1																✓	
		-8.0? yes		per D. Wyll																		

RELINQUISHED BY:	RECEIVED BY:	TURNAROUND REQUIREMENTS	REPORT REQUIREMENTS	INVOICE INFORMATION:	SAMPLE RECEIPT:
[signature] Signature	Elaine Walker Signature	___ 24 hr ___ 48 hr. ___ 5 day	___ I. Routine Report	P.O.# ___	Shipping VIA: ___
Scott Mizonn Printed Name	Elaine Walker Printed Name	___ Standard (10-15 working days)	___ II. Report (includes DUP.MS. MSD, as required, may be charged as samples)	Bill To ___	Shipping #: ___
ERM Firm	Multi Chem Firm	___ Provide Verbal Preliminary Results	___ III. Data Validation Report (includes All Raw Data)		Condition: ___
8/13/98 @ 1510 Date/Time	Date/Time 8/13/98 1510	___ Provide FAX preliminary Results	___ IV. CLP Deliverable Report		
		Requested Report Date ___			Lab No: ___

RELINQUISHED BY:	RECEIVED BY:	SPECIAL INSTRUCTIONS/COMMENTS:
Signature	Signature	
Printed Name	Printed Name	
Firm	Firm	
Date/Time	Date/Time	

808075

ERM-West, Inc.

915 - 118th Avenue SE Suite 130 • Bellevue, WA • 98005 • (425) 462-8591

Date 8/27/98 Weather Clear 70s Page 1 of 1

Chain of Custody Record

Job # 6051.31

Job Location Seattle ANGS

Sampler (signature) [signature]

Printed name Mike Arnold.

Lab Report Recipient Rob Leet

Telephone No. 425 228 8335

Receiving Lab MultiChem Analytical

Address 560 Naches Ave SW Suite 101 Renton WA 98055

Analysis columns: 8015M Purgeables (Gasoline); 8015M Extractables (Diesel); 601 / 8010 Halogenated Hydrocarbons; 602 / 8020 Aromatic Hydrocarbons (BTEX); 8260 VOCs; 624/8240 Purgeables (Volatile Organics); 625/8270 BNAs & Pest. (Semivolatile Organics); 418.1 Tot. Recoverable Petroleum Hydrocarbons; Inorg: Metals; Other

	Sample ID#	Time	W=water S=soil	C=comp G=grab	Volume	Container type	ICED	Preservative	Sampling method	8260 VOCs	Number of Containers	Remarks
1	TB082798-1	—	W	G	2-40ml	VOA	✓	HCl	Grab	✓	2	
2	MW-6-6.5	0706	S	G	1 tube	tube	✓	—	Grab	✓	1	
3	MW-8-6.5R	0845	W	G	2-40ml	VOA	✓	HCl	Grab	✓	2	
4	MW-8-6.5	0845	S	G	1 tube	tube	✓	—	Grab	✓	1	
5	MW-7-6.5	0955	S	G	1 tube	tube	✓	—	Grab	✓	1	
6	MW-10-6.5	1232	S	G	1 tube	tube	✓	—	Grab	✓	1	
7	MW-9-6.5	1352	S	G	1 tube	tube	✓	—	Grab	✓	1	

Precautions:

Conc: ☒ Lo ☐ Med ☐ Hi Ship Via

Total Number of Containers: 9

Sample Relinquished By	Date	Time	Received By	Date	Time	Reason for Transfer (List Shipping Bill Number)
[signature] Company ERM	8/27/98	1630	[signature] Company ERM	8/27/98	1630	Transport to Lab
[signature] Company	8/27/98	1725	[signature] Company MASK	8/27/98	~~1630~~ 1725	

LABORATORY— Please Complete ☐ Samples intact ☐ Samples at 4°C ☐ Samples not leaking ☐ # of containers matches C-of-C ☐ Container tags match C-of-C ☐ Cooler seals intact

Lab sample custodian Signature Date Time

Sample Disposition ☐ Return to Site ☐ Discard ☐ Hold ___ days

FINAL

EW 9/31/98

B-30

Figure B-1
Chain-of-Custody Record

KCSlip4 41490

SEA408020

MultiChem
ANALYTICAL SERVICES
560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 ◆ (425) 228-83[illegible] FAX (425) 228-8336

LAB NUMBER: [illegible]

DATE: 9 / 1 / 98
PAGE: 1 of 1

COMPANY: ERM-WEST
ADDRESS: 915 - 118th Ave SE Suite 130
Bellevue WA 98005
PHONE: (425) 462-8591 FAX (425) 455-3573
PROJ. MGR / CONTACT: Rob Leet
PROJECT NUMBER:
PROJECT NAME: SEATTLE ANGS
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

FUELS: TPH-HCID; BETX / TPH-G BETX / AK101; BETX (by 8021); TPH-G; TPH-D TPHD-extended; 8015 modified; 418.1; 413.2; AK-GRO AK101; AK-DRO AK102 / 103

ORGANIC COMPOUNDS: 8240 / 8260 GCMS Volatiles; 8270 GCMS Semivolatiles; 8081 Pesticides / PCBs; PCB only (by 8081) STD / LL; 8021 Halogenated VOCs; 8021 Aromatic VOCs; 8310 HPLC PAHs; 8041 Phenols; 8151 OC Herbicides

METALS: Metals indicate below*; Total / Dissolved Lead; RCRA Metals (8); PP Metals (13); TAL Metals (23)

TCLP: TCLP 8240 (ZHE); TCLP 8270 Semivolatiles; TCLP 8081 Pesticides; TCLP 8151 Herbicides; TCLP Metals

OTHER

Total # of Containers

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	8240 / 8260 GCMS Volatiles	Total # of Containers
TB090198	9-1-98	—	W	[illegible]	\	2
MW-1-98-1	9-1-98	1135	W	[illegible]	\	2
MW-10-98-1	9-1-98	1215	W	[illegible]	\	2
MW-9-98-1	9-1-98	1300	W	[illegible]	\	4
BS-005P2-98-1	9-1-98	1340	W	[illegible]	\	2
~~BS-006P2-98-1~~	~~9-1-98~~		~~W~~	[illegible]	— JW	~~2~~

Del

SAMPLE RECEIPT: [illegible]

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☐ 7 DAYS
☐ SP
☐ STANDARD

SPECIAL INSTRUCTIONS/COMMENTS:
NOTE: MS/MSD on Sample MW-9-98-1

*METALS NEEDED:

RELINQUISHED BY	RELINQUISHED BY	RELINQUISHED BY
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Scot Mi[illegible]	PRINT NAME:	PRINT NAME:
DATE: 9/1/98 TIME: 1540	DATE: TIME:	DATE: TIME:
COMPANY: ERM-WEST	COMPANY:	COMPANY:

RECEIVED BY	RECEIVED BY	RECEIVED BY
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: J. VAN DICK	PRINT NAME:	PRINT NAME:
DATE: 9/1/98 TIME: 1540	DATE: TIME:	DATE: TIME:
COMPANY: MCAS	COMPANY:	COMPANY:

[illegible]

KCSlip4 41491

SEA408021

MultiChem ANALYTICAL SERVICES

560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 ◆ (425) 228-8335 ◆ FAX (425) 228-8336

LAB NUMBER: 809007

DATE: 9 / 2 / 98
PAGE: 1 of 2

COMPANY: ERM - West
ADDRESS: 915 - 118th Ave SE Suite 1??
Bellevue WA 98???
PHONE: (425) 462 - 8591 FAX (425) 4?? - 3573
PROJ. MGR / CONTACT: Rod Leet
PROJECT NUMBER: 6051.12
PROJECT NAME: Se??? A???
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	FUELS: TPH-HCID	BETX / TPH-G BETX / AK101	BETX (by 8021)	TPH-G	TPH-D TPHD-extended	8015 modified	418.1	413.2	AK-GRO AK101	AK-DRO AK102 / 103	ORGANIC COMPOUNDS: 8240 / 8260 GCMS Volatiles	8270 GCMS Semivolatiles	8081 Pesticides / PCBs	PCB only (by 8081) STD / LL	8021 Halogenated VOCs	8021 Aromatic VOCs	8310 HPLC PAHs	8041 Phenols	8151 OC Herbicides	METALS: Metals indicate below*	Total / Dissolved Lead	RCRA Metals (8)	PP Metals (13)	TAL Metals (23)	TCLP: TCLP 8240 (ZHE)	TCLP 8270 Semivolatiles	TCLP 8081 Pesticides	TCLP 8151 Herbicides	TCLP Metals	OTHER					Total # of Containers
BS006PZ-98-1	9-2-98	0907	W												✓																								2
TB090298	9-2-98	-	W												✓																								2
MW-2-98-1	9-2-98	1015	W												✓																								2
MW-7-98-1	[illegible]	1030	W												✓																								2
MW-3-98-1	[illegible]	1110	W												✓																								2
MW-3-98-1D	[illegible]	1110	W												✓																								2
MW-3-98-1RB	9-2-98	1210	W												✓																								2
MW-5-98-1	9-2-98	1304	W												✓																								2
MW-6-98-1	9-2-98	1355	W												✓																								2
MW-8-98-1	9-2-98	1410	W												✓																								2
MW-4-98-1	9-2-98	1450	W												✓																								2
BS-004PZ-98-1	9-2-98	1530	W												✓																								2

SAMPLE RECEIPT
TOTAL # OF CONTAINERS ☐ YES ☐ NO
COC SEALS PRESENT ☐ YES ☐ NO
COC SEALS INTACT ☐ YES ☐ NO
RECEIVED COLD ☐ YES ☐ NO
RECEIVED INTACT ☐ YES ☐ NO

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☐ 7 DAYS
☐ SP
☒ STANDARD

RELINQUISHED BY	RELINQUISHED BY	RELINQUISHED BY
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: [illegible]	PRINT NAME:	PRINT NAME:
DATE: [illegible] TIME: [illegible]	DATE: TIME:	DATE: TIME:
COMPANY: [illegible]	COMPANY:	COMPANY:

RECEIVED BY	RECEIVED BY	RECEIVED BY
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: J??n R??	PRINT NAME:	PRINT NAME:
DATE: 9/3/98 TIME: 0900	DATE: TIME:	DATE: TIME:
COMPANY: MAS	COMPANY:	COMPANY:

SPECIAL INSTRUCTIONS/COMMENTS:
Note: MS/MSD on BS-004PZ-98-1
Level IV D?? on samples

*METALS NEEDED:

KCSlip4 41492

MultiChem
ANALYTICAL SERVICES

560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 ◆ (425) 228-8335 ◆ FAX (425) 228-8336

LAB NUMBER: [illegible]

DATE: 9 / 2 / 98
PAGE: 2 of 2

COMPANY: ERM-WEST
ADDRESS: 915-118Th Ave SE STE 130
Bellevue WA 98005
PHONE: (425) 462-8591 FAX (425) 455-3573
PROJ. MGR / CONTACT: Pal Leet
PROJECT NUMBER: 6051.32
PROJECT NAME: SEATTLE AINGS
DISPOSAL: ☑ MAS ☐ HOLD ☐ RETURN

FUELS: TPH-HCID; BETX / TPH-G BETX / AK101; BETX (by 8021); TPH-G; TPH-D TPHD-extended; 8015 modified; 418.1; 413.2; AK-GRO AK101; AK-DRO AK102 / 103

ORGANIC COMPOUNDS: 8240 / 8260 GCMS Volatiles; 8270 GCMS Semivolatiles; 8081 Pesticides / PCBs; PCB only (by 8081) STD / LL; 8021 Halogenated VOCs; 8021 Aromatic VOCs; 8310 HPLC PAHs; 8041 Phenols; 8151 OC Herbicides

METALS: Metals indicate below*; Total / Dissolved Lead; RCRA Metals (8); PP Metals (13); TAL Metals (23)

TCLP: TCLP 8240 (ZHE); TCLP 8270 Semivolatiles; TCLP 8081 Pesticides; TCLP 8151 Herbicides; TCLP Metals

OTHER

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	8240 / 8260 GCMS Volatiles	Total # of Containers
BS-004PZ-98-1 FA	9/1/98	1530	W		\	2
BS-004PZ-98-1 FT	9/1/98	1535	W		\	2

SAMPLE RECEIPT
TOTAL # OF CONTAINERS ☐ YES ☐ NO
COC SEALS PRESENT? ☐ YES ☐ NO
COC SEALS INTACT? ☐ YES ☐ NO
RECEIVED COLD? ☐ YES ☐ NO
RECEIVED INTACT? ☐ YES ☐ NO
RECEIVED BY:

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☐ 7 DAYS
☐ SP
☒ STANDARD

SPECIAL INSTRUCTIONS/COMMENTS:
Level IV Data on Samples

*METALS NEEDED:

RELINQUISHED BY:	RELINQUISHED BY:	RELINQUISHED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Scott Alderson	PRINT NAME:	PRINT NAME:
DATE: 9/2/98 TIME: 0900	DATE: TIME:	DATE: TIME:
COMPANY: ERM-WEST	COMPANY:	COMPANY:

RECEIVED BY:	RECEIVED BY:	RECEIVED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: J. Van Dyck	PRINT NAME:	PRINT NAME:
DATE: 9/3/98 TIME: 0900	DATE: TIME:	DATE: TIME:
COMPANY: MAS-R	COMPANY:	COMPANY:

KCSlip4 41493

SEA408023

MultiChem ANALYTICAL SERVICES 560 Naches Ave. SW Suite 101 Renton, WA 98055 (800) 609-0580 ◆ (425) 228-8335 FAX (425) 228-8336

LAB NUMBER: 811080 DATE: 11/24/98 PAGE: 1 of 2

COMPANY: ERM
ADDRESS: 915 - 118th AVE SE Suite 130
Bellevue, WA 98005
DW
PHONE: (425) 462-3573 FAX (425) 455-3573
PROJ. MGR / CONTACT: ROB LEET
PROJECT NUMBER: 6051.32
PROJECT NAME: SEATTLE ANGB
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	TPH-HCID	BETX / TPH-G BETX / AK101	BETX (by 8021)	TPH-G	TPH-D	TPHD-extended	8015 modified	418.1	413.2	AK-GRO AK101	AK-DRO AK102 / 103	8240 / 8260 GCMS Volatiles	8270 GCMS Semivolatiles	8081 Pesticides / PCBs	PCB only (by 8081) STD / LL	8021 Halogenated VOCs	8021 Aromatic VOCs	8310 HPLC PAHs	8041 Phenols	8151 GC Herbicides	Metals indicate below*	Total / Dissolved Lead	RCRA Metals (8)	PP Metals (13)	TAL Metals (23)	TCLP 8240 (ZHE)	TCLP 8270 Semivolatiles	TCLP 8081 Pesticides	TCLP 8151 Herbicides	TCLP Metals	OTHER	Total # of Containers
MW-8-98-2	11/24/98	1000	W	1												/																				3
MW-7-98-2	11/24/98	1030	W	2												/																				3
MW-5-98-2	11/24/98	1100	W	3												/																				3
MW-4-98-2	11/24/98	1120	W	4												/																				3
MW-6-98-2	11/24/98	1200	W	5												/																				3
MW-3-98-2	11/24/98	1230	W	6												/																				3
MW-3-98-2D	11/24/98	1230	W	7												/																				3
MW-3-98-2R	11/24/98	1240	W	8												/																				3
BS-006PZ-98-2	11/24/98	1305	W	9												/																				3
MW-9-98-2	11/24/98	1400	W	10												/																				3
BS-004PZ-98-2	11/25/98	0835	W	11												/																				9
BS-004PZ-98-2 FT	11/25/98	0935	W	12												/																				3

SAMPLE RECEIPT
TOTAL # OF CONTAINERS ☐ YES ☐ NO
COC SEALS PRESENT? ☐ YES ☐ NO
COC SEALS INTACT? ☐ YES ☐ NO
RECEIVED COLD? ☐ YES ☐ NO
RECEIVED INTACT? ☐ YES ☐ NO
RECEIVED MAS

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☐ 7 DAYS
☐ SP
☒ STANDARD

RELINQUISHED BY:	RELINQUISHED BY:	RELINQUISHED BY:
SIGNATURE: Don Wyll	SIGNATURE:	SIGNATURE:
PRINT NAME: Don Wyll	PRINT NAME:	PRINT NAME:
DATE: 11/25/98 TIME: 1145	DATE: TIME:	DATE: TIME:
COMPANY: ERM	COMPANY:	COMPANY:

RECEIVED BY:	RECEIVED BY:	RECEIVED BY:
SIGNATURE: Jonathan VD	SIGNATURE:	SIGNATURE:
PRINT NAME: J. VAN DICK	PRINT NAME:	PRINT NAME:
DATE: 11/25/98 TIME: 1150	DATE: TIME:	DATE: TIME:
COMPANY: MAS-R	COMPANY:	COMPANY:
MAS LOG IN:	SUBCONTRACT LAB:	PO #:

SPECIAL INSTRUCTIONS/COMMENTS:
MS/MSD on ~~BS-006~~ BS-004PZ-98-2
Level IV Doc on All samples

*METALS NEEDED:

EW 11/30/98

KCSlip4 41494

SEA408024

MultiChem ANALYTICAL SERVICES

560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 ♦ (425) 228-8335 ♦ FAX (425) 228-8336

LAB NUMBER: 811080

DATE: 11/25/98
PAGE: 2 of 2

COMPANY: ERM
ADDRESS: 915 118th Ave SE Suite 130
Bellevue, WA 98005
PHONE: (425) 462-8591 FAX (425) 455-3573
PROJ. MGR / CONTACT: Rob Leet
PROJECT NUMBER: 6051.32
PROJECT NAME: Seattle ANGS
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

Analyses listed on form:
- FUELS: TPH-HCID; BETX / TPH-G BETX / AK101; BETX (by 8021); TPH-G; TPH-D TPH(D)-extended; 8015 modified; 418.1; 413.2; AK-GRO AK101; AK-DRO AK102 / 103
- ORGANIC COMPOUNDS: 8240 / 8260 GCMS Volatiles; 8270 GCMS Semivolatiles; 8081 Pesticides / PCBs; PCB only (by 8081) STD / LL; 8021 Halogenated VOCs; 8021 Aromatic VOCs; 8310 HPLC PAHs; 8041 Phenols; 8151 GC Herbicides
- METALS: Metals indicate below*; Total / Dissolved Lead; RCRA Metals (8); PP Metals (13); TAL Metals (23)
- TCLP: TCLP 8240 (ZHE); TCLP 8270 Semivolatiles; TCLP 8081 Pesticides; TCLP 8151 Herbicides; TCLP Metals
- OTHER
- Total # of Containers

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	8240 / 8260 GCMS Volatiles	Total # of Containers
BS-004PZ-98-2 FA	11/25/98	0936	W	13	/	3
MW-1-98-2	11/25/98	1000	W	14	/	3
MW-10-98-2	11/25/98	1030	W	15	/	3
BS-005PZ-98-2	11/25/98	1100	W	16	/	3
TB112498-1	11/24/98	—	W	17	/	3
MW-2-98-2	RCL 11/25/98	1309	W	18	/	3

SAMPLE RECEIPT
TOTAL # OF CONTAINERS ☐ SP ☐ NO
COC SEALS PRESENT? ☐ YES ☐ NO
COC SEALS INTACT? ☐ YES ☐ NO
RECEIVED COLD? ☐ YES ☐ NO
RECEIVED INTACT? ☐ YES ☐ NO
RECEIVED AS ...

TAT: ☐ 24 HOURS ☐ 48 HOURS ☐ 72 HOURS ☐ 7 DAYS ☐ SP ☒ STANDARD

RELINQUISHED BY:
SIGNATURE: Don Wyll
PRINT NAME: Don Wyll
DATE: 11/25/98 TIME: 1145
COMPANY: ERM

RECEIVED BY:
SIGNATURE: J. van Dyck
PRINT NAME: J. VAN DYCK
DATE: 11/25/98 TIME: 1150
COMPANY: MAS R

RELINQUISHED BY: SIGNATURE: PRINT NAME: DATE: TIME: COMPANY:
RECEIVED BY: SIGNATURE: PRINT NAME: DATE: TIME: COMPANY:
RELINQUISHED BY: SIGNATURE: PRINT NAME: DATE: TIME: COMPANY:
RECEIVED BY: SIGNATURE: PRINT NAME: DATE: TIME: COMPANY:

MAS USE ONLY
SUBCONTRACT LAB

SPECIAL INSTRUCTIONS/COMMENTS:
Level IV Doc
MS/MSD on BS004PZ-98-2

*METALS NEEDED:

KCSlip4 41495

SEA408025

MultiChem ANALYTICAL SERVICES

560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 • (425) 228-8335 FAX (425) 228-8336

LAB NUMBER: [illegible]

DATE: 2/24/99
PAGE: 1 of 2

COMPANY: ERM
ADDRESS: 915 118th AVE SE
suite 130
Bellevue, WA 98005
PHONE: (425) 462-8591 FAX (425) 455 3573
PROJ. MGR / CONTACT: ROB LEET
PROJECT NUMBER: 6051.32
PROJECT NAME: SEATTLE ANGS
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	TPH-HCID	BETX / TPH-G BETX / AK101	BETX (by 8021)	TPH-G	TPH-D TPHD-extended	8015 modified	418.1	413.2	AK-GRO AK101	AK-DRO AK102 / 103	8240 / 8260 GCMS Volatiles	8270 GCMS Semivolatiles	8081 Pesticides / PCBs	PCB only (by 8081) STD / LL	8021 Halogenated VOCs	8021 Aromatic VOCs	8310 HPLC PAHs	8041 Phenols	8151 OC Herbicides	Metals indicate below*	Total / Dissolved Lead	RCRA Metals (8)	PP Metals (13)	TAL Metals (23)	TCLP 8240 (ZHE)	TCLP 8270 Semivolatiles	TCLP 8081 Pesticides	TCLP 8151 Herbicides	TCLP Metals	OTHER					Total # of Containers
TB022499-1	2/24/99	—	W	1											\																								2
BS-006PZ-99-1	2-24-99	0855	W	[illegible]											\																								3
mw-9-99-1	2-24-99	0940	W	3											\																								3
mw-10-99-1	2-24-99	1010	W	[illegible]											\																								3
mw-1-99-1	2-24-99	1040	W	[illegible]											\																								3
BS-004PZ-99-1	2-24-99	1115	W	[illegible]											\																								3
mw-2-99-1	2-24-99	1200	W	7											\																								3
BS-005PZ-99-1	2-24-99	1235	W	[illegible]											\																								3
mw-8-99-1FT	2/24/99	1258	W	[illegible]											\																								3
mw-8-99-1FA	2/24/99	1255	W	[illegible]											\																								3
mw-8-99-1	2/24/99	1310	W	[illegible]											\																								3
mw-8-99-1D	2/24/99	1310	W	[illegible]											\																								3

SAMPLE RECEIPT	TAT:
TOTAL # OF CONTAINERS ☐ YES ☐ NO	☐ 24 HOURS
COC SEALS PRESENT ☐ YES ☐ NO	☐ 48 HOURS
COC SEALS INTACT ☐ YES ☐ NO	☐ 72 HOURS
RECEIVED COLD ☐ YES ☐ NO	☐ 7 DAYS
RECEIVED INTACT ☐ YES ☐ NO	☐ SP
RECEIVED VIA:	☒ STANDARD

RELINQUISHED BY:	RELINQUISHED BY:	RELINQUISHED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Don Wyll	PRINT NAME:	PRINT NAME:
DATE: 2-24-99 TIME: 1440	DATE: TIME:	DATE: TIME:
COMPANY: ERM	COMPANY:	COMPANY:

RECEIVED BY:	RECEIVED BY:	RECEIVED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Kim Lofgren	PRINT NAME:	PRINT NAME:
DATE: 2/24/99 TIME: 1440	DATE: TIME:	DATE: TIME:
COMPANY: MASR	COMPANY:	COMPANY:

MAS USE ONLY: SUBCONTRACT LAB

SPECIAL INSTRUCTIONS/COMMENTS:
Level IV Doc. on All samples

*METALS NEEDED:

KCSlip4 41496

SEA408026

MultiChem ANALYTICAL SERVICES

560 Naches Ave. SW Suite 101 Renton, WA 98055
(800) 609-0580 • (425) 228-8335 • FAX (425) 228-8336

LAB NUMBER: [illegible]

DATE: 2/24/99
PAGE: 2 of 2

COMPANY: ERM
ADDRESS: 915-118th AVE SE
Suite 130
Bellevue WA 98005
PHONE: (425)-462-8591 FAX (425) 425-455-3573
PROJ. MGR / CONTACT: Ron Leet
PROJECT NUMBER: 6051.32
PROJECT NAME: Seattle ANGS
DISPOSAL: ☐ MAS ☐ HOLD ☐ RETURN

ANALYSES: FUELS: TPH-HCID, BETX / TPH-G BETX / AK101, BETX (by 8021), TPH-G, TPH-D HD-extended, 8015 modified, 418.1, 413.2, AK-GRO AK101, AK-DRO AK102 / 103. ORGANIC COMPOUNDS: 8240 / 8260 GCMS Volatiles, 8270 GCMS Semivolatiles, 8081 Pesticides / PCBs, PCB only (by 8081) STD / LL, 8021 Halogenated VOCs, 8021 Aromatic VOCs, 8310 HPLC PAHs, 8041 Phenols, 8151 GC Herbicides. METALS: Metals indicate below*, Total / Dissolved Lead, RCRA Metals (8), PP Metals (13), TAL Metals (23). TCLP: TCLP 8240 (ZHE), TCLP 8270 Semivolatiles, TCLP 8081 Pesticides, TCLP 8151 Herbicides, TCLP Metals. OTHER. Total # of Containers.

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	8240 / 8260 GCMS Volatiles	Total # of Containers
MW-4-99-1R	2-24-99	1315	W		✓	3
MW-4-99-1	2-24-99	1342	W		✓	3
MW-4-99-1D	2-24-99	1342	W		✓	[illegible]

DW

SAMPLE RECEIPT
TOTAL # OF CONTAINERS
CUSTODY SEALS
COC SEALS INTACT
RECEIVED GOOD COND./COLD
RECEIVED INTACT
RECEIVED VIA

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☐ 7 DAYS
☐ SP
☒ STANDARD

RELINQUISHED BY:
SIGNATURE: [signature]
PRINT NAME: Don Wyll
DATE: 2-24-99 TIME: 1440
COMPANY: ERM

RELINQUISHED BY:
SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

RELINQUISHED BY:
SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

RECEIVED BY:
SIGNATURE: [signature]
PRINT NAME: Kim Lothner
DATE: 2/24/99 TIME: 14:40
COMPANY: MABR

RECEIVED BY:
SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

RECEIVED BY:
SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

SPECIAL INSTRUCTIONS/COMMENTS:
MS/MSD on MW-4-99-1
Level II ~~Documentation~~ Doc on ALL samples
(w) 4/25/99

*METALS NEEDED:

MATRIX USE ONLY / SUBCONTRACTED TO:

KCSlip4 41497

SEA408027

MultiChem ANALYTICAL SERVICES

560 Naches Ave. SW Suite 1[illegible] Renton, WA 98055
(800) 609-0580 • (425) 228-83[illegible] • FAX (425) 228-8336

[redacted]

DATE: 2/25/99
PAGE: 1 of 1

COMPANY: ERM
ADDRESS: 915 - 118th Ave SE
Suite 130
Bellevue WA 98005
PHONE: (425) 462 - 8591 FAX: (425) 455 - 3573
PROJ. MGR / CONTACT: Rob Leet
PROJECT NUMBER: 6051.32
PROJECT NAME: Seattle ANGS
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

Analyses: FUELS (TPH-HCID; BETX / TPH-G BETX / AK101; BETX (by 8021); TPH-G; TPH-D TPHD-extended; 8015 modified; 418.1; 413.2; AK-GRO AK101; AK-DRO AK102 / 103); ORGANIC COMPOUNDS (8240 / 8260 GCMS Volatiles; 8270 GCMS Semivolatiles; 8081 Pesticides / PCBs; PCB only (by 8081) STD / LL; 8021 Halogenated VOCs; 8021 Aromatic VOCs; 8310 HPLC PAHs; 8041 Phenols; 8151 OC Herbicides); METALS (Metals indicate below*; Total / Dissolved Lead; RCRA Metals (8); PP Metals (13); TAL Metals (23)); TCLP (TCLP 8240 (ZHE); TCLP 8270 Semivolatiles; TCLP 8081 Pesticides; TCLP 8151 Herbicides; TCLP Metals); OTHER; Total # of Containers

[redacted]

Sample ID	Date	Time	Matrix	[redacted]	8240 / 8260 GCMS Volatiles	Total # of Containers
TB022599-1	2-25-99	–	W	[redacted]	\	2
MW-3-99-1	2-25-99	0850	W	[redacted]	\	3
MW-7-99-1	2-25-99	0935	W	[redacted]	\	3
MW-6-99-1	2-25-99	1000	W	[redacted]	\	3
MW-5-99-1	2-25-99	1035	W	[redacted]	\	7

DW

[redacted]

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☐ 7 DAYS
☐ SP
☒ STANDARD

[redacted]

SIGNATURE: Don Wyll
PRINT NAME: DON WYLL
DATE: 2-25-99 TIME: 1115
COMPANY: ERM

SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

[redacted]

SIGNATURE: Elaine Walker
PRINT NAME: Elaine Walker
DATE: 2/25/99 TIME: 1120
COMPANY: MultiChem

SIGNATURE:
PRINT NAME:
DATE: TIME:
COMPANY:

SIGNATURE:
PRINT NAME:
DATE: TIME: EW
COMPANY:

[redacted]

SPECIAL INSTRUCTIONS/COMMENTS:
Level IV Documentation on all samples

~~MS/MSD on MW-3-99-1~~
EW 3/4/99 EW 2/25/99

*METALS NEEDED:

KCSlip4 41498

SEA408028

MultiChem ANALYTICAL SERVICES 560 Naches Ave. SW Suite 1[illegible] Renton, WA 98055 (800) 609-0580 • (425) 228-8[illegible] • FAX (425) 228-8336

LAB NUMBER: [illegible]

DATE: 5/18/99
PAGE: 1 of 2

COMPANY: ERM
ADDRESS: 915-118th Ave SE Suite 130
Bellevue WA 98005
PHONE: (425) 462-8591 FAX (425) 455-3573
PROJ. MGR / CONTACT: Rob Leet
PROJECT NUMBER: 6051.32
PROJECT NAME: Seattle Angs
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

Groups: FUELS (TPH-HCID through AK-DRO); ORGANIC COMPOUNDS (8240 through 8151); METALS (Metals indicate below* through TAL Metals); TCLP (TCLP 8240 through TCLP Metals); OTHER

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	TPH-HCID	BETX / TPH-G BETX / AK101	BETX (by 8021)	TPH-G	TPH-D TPHD-extended	8015 modified	418.1	413.2	AK-GRO AK101	AK-DRO AK102 / 103	8240 / (8260) GCMS Volatiles	8270 GCMS Semivolatiles	8081 Pesticides / PCBs	PCB only (by 8081) STD / LL	8021 Halogenated VOCs	8021 Aromatic VOCs	8310 HPLC PAHs	8041 Phenols	8151 OC Herbicides	Metals indicate below*	Total / Dissolved Lead	RCRA Metals (8)	PP Metals (13)	TAL Metals (23)	TCLP 8240 (ZHE)	TCLP 8270 Semivolatiles	TCLP 8081 Pesticides	TCLP 8151 Herbicides	TCLP Metals	OTHER					Total # of Containers
MW-8-99-2FT	5/18/99	0730	W	1											X																								3
MW-8-99-2FA	5/18/99	0745	W	2											X																								3
MW-8-99-2	5/18/99	0755	W	3											X																								6
MW-8-99-2D	5/18/99	0755	W	4											X																								3
MW-6-99-2	5/18/99	0825	W	[illegible]											X																								3
MW-7-99-2	5/18/99	0845	W	[illegible]											X																								3
TB051899-1	5/18/99	—	W	7											X																								2
MW-4-99-2	5/18/99	0935	W	8											X																								3
MW-4-99-2R	5/18/99	0930	W	9											X																								3
MW-5-99-2	5/18/99	0910	W	10											X																								3
MW-3-99-2	5/18/99	0955	W	11											X																								3
BS-005DZ-99-2	5/18/99	1030	W	12											X																								3

SAMPLE RECEIPT
TOTAL # OF CONTAINERS ☐ YES ☐ NO
COC SEALS PRESENT? ☐ YES ☐ NO
COC SEALS INTACT? ☐ YES ☐ NO
RECEIVED GOOD COND.? ☐ YES ☐ NO
RECEIVED INTACT? ☐ YES ☐ NO
RECEIVED [illegible]

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☒ 7 DAYS
☐ SP
☐ STANDARD

RELINQUISHED BY:	RELINQUISHED BY:	RELINQUISHED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Don Wyll	PRINT NAME:	PRINT NAME:
DATE: 5/18/99 TIME: 1035	DATE: TIME:	DATE: TIME:
COMPANY: ERM	COMPANY:	COMPANY:

RECEIVED BY:	RECEIVED BY:	RECEIVED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: [illegible]	PRINT NAME:	PRINT NAME:
DATE: 5/19/99 TIME: 1040	DATE: TIME:	DATE: TIME:
COMPANY: MAS [illegible]	COMPANY:	COMPANY:

MAS USE ONLY: SUBCONTRACT LAB: [illegible] TO: [illegible]

SPECIAL INSTRUCTIONS/COMMENTS:
MS/MSD on MW-8-99-2
Level IV Doc. on ALL samples.

*METALS NEEDED:

KCSlip4 41499

SEA408029

MultiChem
ANALYTICAL SERVICES

560 Naches Ave. SW Suite Renton, WA 98055
(800) 609-0580 • (425) 228-83[illegible] • FAX (425) 228-8336

LAB NUMBER: 9050[illegible]

DATE: 5/18/99
PAGE: 2 of 2

COMPANY: ERM
ADDRESS: 915 118th Ave SE suite 130
Bellevue WA 98005
PHONE: (425) 462-8591 FAX (425) 455-3573
PROJ. MGR / CONTACT: Ross Leet
PROJECT NUMBER: 6051.32
PROJECT NAME: Seattle Angs
DISPOSAL: ☒ MAS ☐ HOLD ☐ RETURN

Analyses: FUELS (TPH-HCID; BETX / TPH-G BETX / AK101; BETX (by 8021); TPH-G; TPH-D TPHD-extended; 8015 modified; 418.1; 413.2; AK-GRO AK101; AK-DRO AK102 / 103) — ORGANIC COMPOUNDS (8240 / 8260 GCMS Volatiles; 8270 GCMS Semivolatiles; 8081 Pesticides / PCBs; PCB only (by 8081) STD / LL; 8021 Halogenated VOCs; 8021 Aromatic VOCs; 8310 HPLC PAHs; 8041 Phenols; 8151 OC Herbicides) — METALS (Metals indicate below*; Total / Dissolved Lead; RCRA Metals (8); PP Metals (13); TAL Metals (23)) — TCLP (TCLP 8240 (ZHE); TCLP 8270 Semivolatiles; TCLP 8081 Pesticides; TCLP 8151 Herbicides; TCLP Metals) — OTHER — Total # of Containers

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	8240 / 8260 GCMS Volatiles	Total # of Containers
BS-006PZ-99-2	5/13/99	1110	W	13	/	
MW-2-99-2	5/13/99	1130	W	14	/	3
MW-9-99-2	5/13/99	1210	W	15	/	3
BS-004PZ-99-2	5/13/99	[illegible]	W	16	/	
MW-10-99-2	5/13/99	0935	W	17	/	3
MW-1-99-2	5/13/99	1000	W	18	/	3

SAMPLE RECEIPT
TOTAL # OF CONTAINERS ☐ YES ☐ NO
COC SEALS PRESENT? ☐ YES ☐ NO
COC SEALS INTACT? ☐ YES ☐ NO
RECEIVED COLD? ☐ YES ☐ NO
RECEIVED INTACT? ☐ YES ☐ NO
RECEIVED VIA:

TAT:
☐ 24 HOURS
☐ 48 HOURS
☐ 72 HOURS
☒ 7 DAYS
☐ 5P
☐ STANDARD

SPECIAL INSTRUCTIONS/COMMENTS:
Level IV Doc. on all samples

*METALS NEEDED:

RELINQUISHED BY:	RELINQUISHED BY:	RELINQUISHED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: Don Coyle	PRINT NAME:	PRINT NAME:
DATE: 5/19/99 TIME: 1035	DATE: TIME:	DATE: TIME:
COMPANY: ERM	COMPANY:	COMPANY:

RECEIVED BY:	RECEIVED BY:	RECEIVED BY:
SIGNATURE: [signature]	SIGNATURE:	SIGNATURE:
PRINT NAME: [illegible]	PRINT NAME:	PRINT NAME:
DATE: 5/19/99 TIME: 1020	DATE: TIME:	DATE: TIME:
COMPANY: MAS	COMPANY:	COMPANY:

MAS USE ONLY: SUBCONTRACT LAB: PO #:

KCSlip4 41500

SEA408030